CASE REPORT

Perceptual Learning for Rehabilitation in Traumatic Optic Neuropathy

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ABSTRACT

Traumatic optic neuropathy is a cause of sudden irreversible visual loss due to optic nerve damage following trauma. Reports of improvement have been noted after observation alone, treatment with corticosteroids, and surgical decompression. However, final visual acuity may not be predictable, with individual patients having little improvement in visual function despite therapy. Perceptual learning improves visual functions by improving the neural processing so as to allow image perception at low signal-to-noise ratios. The case report describes the beneficial effect of perceptual learning in traumatic optic neuropathy, the first to describe the use of perceptual learning in an optic neuropathy. A larger case-controlled study of the effect of perceptual learning in optic neuropathies is required to substantiate the beneficial effect and elaborate the scale of improvement that may be possible with this form of therapy.

Keywords: Contrast sensitivity, Gabor gratings, perceptual learning, rehabilitation, traumatic optic neuropathy, visual acuity

INTRODUCTION

Perceptual learning is a process of learning improved skills of perception ranging from a simple sensory discrimination to complex categorisations of spatial and temporal patterns.¹ The improvement in visual performance after training has been well established and is usually task specific, suggesting that the changes occur at early stages of cortical processing.² However, the improvement achieved through perceptual learning generalises more for complex tasks than for simple ones.³ Therefore, training to improve a fundamental function may contribute to enhance performance along a wide range of more complex functions, which may be useful functionally, and measurable clinically.⁴

The present case report describes the visual results of perceptual training with varying contrast Gabor gratings in a case of traumatic optic neuropathy with poor visual gain following conventional therapy in the form of optic canal decompression and corticosteroids.

CASE REPORT

A 27-year-old man presented with loss of vision in the left eye following a road traffic accident. There was a history of unconsciousness of 6 hours and a nasal bleed lasting 24 hours.

Examination revealed a visual acuity limited to light perception in the left eye with an afferent pupillary defect of 3 log units. The fundus examination was within normal limits. Ocular movements were full and normal. Examination of the right eye was normal, with a vision of 0.0 logMAR units on the early treatment diabetic retinopathy (ETDRS) chart. Computerised tomographic (CT) scan of the left eye revealed a fracture at the orbital apex involving the optic canal (Figure 1).

Pulse-dose corticosteroids were given in doses of 1g a day for 3 days followed by tapering oral corticosteroids. Surgical decompression of the optic nerve was also performed using an orbital/transethmoidal route with an incision placed in the caruncle of the left eye.

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FIGURE 1 CT Scan showing the presence of a fracture at the orbital apex involving the optic canal.

The visual acuity of the left eye improved to 1.0 logMAR on ETDRS chart after 2 months and remained at that level with no further improvement at 6-month follow-up. The contrast sensitivity at 6 months was 0.45 on Pelli-Robson's chart and the near visual acuity at 25cm was N36. There was no refractive error and fundus examination revealed a pale disc with normal vasculature and macula.

Perceptive learning sessions were commenced using Gabor gratings with varying contrast (100% contrast to 1%). The spatial frequency of the target was increased as the session progressed. Flankers in the form of Gabor gratings surrounding the target were also created. The distance and number of these flankers were varied, with the separation being reduced progressively as training progressed. The learning stimulus was provided binocularly with both eyes open.

Each session, lasting 30–40 minutes, had 8 blocks of 150 trials each. In all, 8000 trials were given over 7 sessions in 3 weeks.

Post training, the visual acuity improved to 0.3 log units on the ETDRS chart, contrast sensitivity to 1.35, and the near vision to N8 at 25 cm. The crowding ratio calculated by determining the ratio of the acuity for single letters and the acuity for the whole ETDRS chart reduced from 2.9 to 1.3 after perceptual learning exercises. Stereoacuity improved from absent stereopsis to 60 seconds of arc on the TNO test for stereoscopic vision.

The visual acuity was maintained at this level after 6 months of training, with contrast sensitivity function improving to 1.65, indicating continued improvement. No additional perceptual learning sessions were required to maintain visual function.

DISCUSSION

Perceptual learning has been shown to enhance visual function in a variety of ocular disorders presenting

with optical blur by increasing the efficiency of neural processing.^{5,6} The present case report illustrates the efficacy of perceptual learning in traumatic optic neuropathy; the first reported description of the effect of perceptual learning in an optic neuropathy where conventional management is primarily directed to limiting the extent of damage and preventing progression.⁷

The mechanism of the action of perceptual learning has been proposed to be due to blur adaptation.⁸ However, being a transient phenomenon, adaptation to blur may not be wholly responsible for the beneficial effect. The mechanism of enhancement of neural sensitivity so as to enable image processing at low signal-to-noise ratios has been proposed and may account for the improvement following perceptual learning.⁶ Blur detection and discrimination of single blurred edges have been demonstrated to be contrast detection tasks⁹ and improvement of contrast detection through perceptual learning may enhance processing of blurred images.

Gabor gratings are sinusoidal gratings with a gaussian envelope, which can be varied in contrast, spatial frequency, size, orientation, and phase, as also background contrast. The use of flankers at different distances from the target has been proposed to modify lateral interactions and reduce crowding ratios.¹⁰ Visual acuity assessment requires both resolution of targets as well as compensation of crowding phenomena that may be limiting the reading of a letter in the test chart.

Transfer of learning of Gabor orientation identification to the fellow eye has been noted previously,¹¹ indicating a high-level locus of learning beyond the primary visual cortex. This phenomenon allows the use of high-spatial-frequency gratings at low contrast, which may not be visible by the affected eye due to poor visual function, to be presented binocularly for enhanced learning, as was used in the case report.

The present case report describes the use of Gabor gratings of varying contrast and spatial frequency with flankers for perceptual training. This enhanced both blur discrimination by enhanced contrast detection and reduced effects of crowding due to alterations in the lateral interactions of neurons involved in image processing. Clinically both contributed to a better visual acuity.

The case report illustrates the beneficial effect of perceptual learning in a clinical setting of traumatic optic neuropathy, which is a model for other chronic optic neuropathies such as glaucoma. This is the first reported use of perceptual learning tasks to improve vision in an optic neuropathy. This needs to be followed by case-controlled studies to substantiate the beneficial effect and elaborate the nature and scale of visual improvement that may be possible with this form of therapy.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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