

NEAR INFRARED SPECTROSCOPY AS A NON-INVASIVE ASSESSMENT OF CORTICAL ABNORMALITY IN MIGRAINE?

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1. INTRODUCTION

Migraine is a brain disorder associated with debilitating episodic head pain that afflicts approximately 7% of men and 20% women. It has been estimated to cost US employers about \$13 billion per annum.^{1, 2} There is an abnormal haemodynamic response to strong visual stimuli in migraine that has been measured using functional magnetic resonance imaging (fMRI).³ An alternative optical technique, near infrared spectroscopy (NIRS), is more suitable than fMRI for mass studies because of its low cost. Its simplicity and portability offer the potential for widespread use in outpatient clinics. We report preliminary work designed, ultimately, to evaluate the use of NIRS as a screening and therapy evaluation tool in migraine.

2. BACKGROUND: MIGRAINE

2.1. Strong Patterns

Patterns of stripes (gratings) vary predictably in only one dimension and have been widely used in vision research. The gratings that have parameters optimal for visibility at low contrast⁴ are also those that at high contrast interfere maximally with the visibility of other stimuli with which they are combined (in studies of visual masking⁵). Patterns with the same characteristics induce the highest amplitude evoked potentials⁶ and are

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associated with the greatest fMRI blood oxygenation level dependent (BOLD) signal⁷. In brief, they are stimuli to which the visual system is in a general sense maximally sensitive, and will be referred to here as *strong* patterns.

2.2. Aversion, Perceptual Distortions and Seizures in Response to Strong Patterns

Strong patterns can induce a variety of perceptual distortions – illusions of colour, shape and motion. The origin of the illusions is unknown, despite a century of study, although various mechanisms have been proposed.⁸ Some individuals are far more susceptible than others to these distortions, usually individuals with frequent headaches.⁸ The illusion susceptibility increases in the 24 hours prior to a headache.⁹ If the headaches are unilateral, the distortions predominate in one lateral visual field.⁸ Individuals with migraine find the patterns aversive¹⁰ and these individuals are particularly susceptible to the perceptual distortions that the patterns evoke.⁸ In migraine with aura, the distortions tend to occur interictally in the visual field affected by the aura.⁸

Strong patterns can induce seizures in patients with photosensitive epilepsy.^{11, 12} The patterns that induce paroxysmal epileptiform EEG activity in patients with photosensitive epilepsy are very similar indeed to the characteristics of patterns that provoke perceptual distortions in normal observers and, to a greater extent, those with migraine.⁸

2.3. Cortical Abnormality in Migraine

The cerebral cortex responds abnormally in migraine. The abnormality is poorly understood, although there are several disparate but convergent lines of evidence, recently reviewed,¹³ consistent with the hypothesis that the cortex is hyperexcitable: migraine and epilepsy are co-morbid conditions¹⁴ and several anticonvulsant drugs have been shown to prevent migraine in randomised controlled trials¹⁵. In migraineurs (1) magnetic stimulation of the visual cortex stimulates phosphenes more readily,¹⁶ (2) the evoked potential fails to show the usual habituation with repeated stimulation,^{17, 18} (3) *strong* (epileptogenic) patterns are aversive,¹⁰ (4) the fMRI BOLD response to *strong* patterns is selectively elevated.³

We hypothesise that the perceptual distortions occur because a spread of excitation causes visual neurons to fire inappropriately. According to this hypothesis, the degree of susceptibility to distortions increases with, and reflects, the degree of cortical hyperexcitability.

2.4. Triggering of Headaches

When they are asked, about 40% of patients with migraine will report visually provoked attacks.¹⁹ A substantial proportion report that flicker induces attacks, and a smaller proportion are aware that patterns of stripes can also be a problem. The role of vision in the induction of migraine attacks has received only one investigation in a dozen epidemiologic studies of migraine with a sample size of 1,000-20,000 patients.¹⁹

The possibility that many headaches are visually provoked has been suggested by (1) double-masked studies that have shown the imperceptible high frequency flicker