Journal of Optometry (2016) 9, 110–117

Journal of Optometry

www.journalofoptometry.org

ORIGINAL ARTICLE

The effect of spectral filters on VEP and alpha-wave responses

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Received 31 March 2015; accepted 4 July 2015
Available online 17 August 2015

KEYWORDS
Visual-evoked potential (VEP);
Electrophysiology;
Brain injury;
Intuitive Colorimeter;
Colored filters

Abstract
Purpose: Spectral filters are used to treat light sensitivity in individuals with traumatic brain injury (TBI); however, the effect of these filters on *normal* visual function has not been elucidated. Thus, the current study aimed to determine the effect of spectral filters on objectively-measured visual-evoked potential (VEP) and alpha-wave responses in the visually-normal population.
Methods: The full-field (15°H × 17°V), pattern-reversal VEP (20′ check size, mean luminance 52 cd/m^2) was administered to 20 visually-normal individuals. They were tested with four Intuitive-Colorimeter-derived, broad-band, spectral filters (i.e., gray/neutral density, blue, yellow, and red), which produced similar luminance values for the test stimulus. The VEP N75 and P100 latencies, and VEP amplitude, were recorded. Power spectrum analysis was used to derive the respective powers at each frequency, and peak frequency, for the selected 9–11 Hz components of the alpha band.
Results: Both N75 and P100 latencies increased with the addition of each filter when compared to baseline. Additionally, each filter numerically reduced intra-session amplitude variability relative to baseline. There were no significant effects on either the mean VEP amplitude or alpha wave parameters.
Conclusions: The Intuitive Colorimeter filters significantly increased both N75 and P100 latencies, an effect which is primarily attributable (~75%) to luminance, and in some cases, specific spectral effects (e.g., blue and red). VEP amplitude and alpha power were not significantly affected. These findings provide an important reference to which either amplitude or power changes in light-sensitive, younger clinical groups can be compared.

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http://dx.doi.org/10.1016/j.optom.2015.07.003

PALABRAS CLAVE
Potencial evocado visual (PEV);
Filtro espectral;
Color;
Electrofisiología;
Corteza visual;
Lesión cerebral;
Colorímetro Intuitivo;
Filtros coloreados

Efecto de los filtros espectrales sobre el PVE y las respuestas de las ondas alfa

Resumen
Objetivo: Los filtros espectrales se utilizan para tratar la sensibilidad a la luz en individuos con lesión cerebral traumática (TBI); sin embargo, no se ha esclarecido el efecto de estos filtros sobre la función visual normal. Por ello, el estudio actual trató de determinar el efecto de los filtros espectrales sobre el potencial evocado visual (PVE) y las respuestas de las ondas alfa, medido objetivamente en la población con visión normal.
Métodos: Se aplicó un PVE de campo completo (15°H × 17°V), y patrón invertido (tamaño de estímulo de 20', y luminancia media de 52 cd/m^2) a veinte individuos con visión normal. Se realizó la prueba utilizando cuatro filtros espectrales de banda ancha, derivados del Colorímetro Intuitivo (densidad gris/neutra, azul, amarillo y rojo), que produjeron unos valores de luminancia similares para los estímulos de la prueba. Se registraron las latencias N75 y P100, y la amplitud del PVE. Se utilizó el análisis del espectro de potencia para calcular las respectivas potencias en cada frecuencia, así como la frecuencia máxima, para los componentes seleccionados de 9–11 Hz de la banda alfa.
Resultados: Ambas latencias N75 y P100 se incrementaron con la incorporación de cada filtro, en comparación a la línea basal. Además, cada filtro redujo numéricamente la variabilidad de la amplitud intra-sesión, en relación a la línea basal. No se produjeron efectos significativos sobre la amplitud del PVE medio o los parámetros de la onda alfa.
Conclusiones: Los filtros del Colorímetro Intuitivo redujeron considerablemente las latencias N75 y P100, un efecto que es principalmente atribuible a la luminancia (∼75%), y en algunos casos a los efectos espectrales específicos (es decir, el azul y el rojo). La amplitud del PVE y la potencia alfa no se vieron significativamente afectados. Estos hallazgos aportan una importante referencia para poder comparar tanto los cambios de amplitud como de potencia en los grupos clínicos de personas más jóvenes, con sensibilidad a la luz.

Introduction

Individuals who have suffered a traumatic brain injury (TBI) often report several post-injury visual sequelae. For example, up to 50% of patients experience persistent light sensitivity for up to one to two years, or more, post injury,[1–3] the severity of which ranges from mild to marked. Some light sensitive individuals also experience difficulties in scotopic environments; thus, TBI-induced light adaptation defects have been termed ''dual-system deficits'' (i.e., photopic and scotopic[1,4]): a shift in the mean light-adaptation level (i.e., gain control) has been suggested to explain the simultaneous presence of reduced scotopic sensitivity and enhanced photopic sensitivity.[2] The origin of this alteration is thought to be cortical, as the deficits persist despite normal ocular health and electroretinogram recordings.[5] Thus, the visual-evoked potential serves as a logical starting point for examination of light sensitive individuals following TBI.

If cortical processing abnormalities are present, can they be remediated? Spectral filters may provide insight regarding this question. Spectral filters used in these patients are broad-band, which selectively transmit short, medium, or long-wavelength light: they are often prescribed to reduce or relieve post-injury light sensitivity.[6] Further investigation is warranted in the TBI population for two reasons. First, there is a paucity of research regarding spectral filters in a TBI cohort: *objective* reports of filter efficacy have been derived from other clinical populations. For example, Riddell et al. found increased steady state VEP amplitudes in a group of children with a diagnosis of migraines when a specific spectral filter was worn.[7] Similarly, Huang et al. documented reduced cortical hyperexcitability in extrastriate visual cortex when migraineurs wore their precision tint.[8] The increase in VEP amplitude and reduction in hyperexcitability suggest that neural activity may be altered by wavelength-dependent processes; however, further investigations are needed to clarify the mechanism underlying these changes. Moreover, the effect of such filters must first be documented in visually-normal individuals, so that any changes in a given clinical population may be considered unique. Second, there is no standardized wavelength ''prescription'' for a given problem: confusion and skepticism have arisen from colorimetry systems which aim to reduce *one* symptom with a spectral bandwidth *unique for each patient*.[9,10] Utilization of filters which selectively transmit short, medium, and long wavelength light is necessary for delineation of wavelength specific effects. Thus, prior to studies which aim to validate the use of spectral filters in clinical groups (e.g., TBI, migraine), steps must be taken to address the aforementioned concerns. Therefore, the goal of the current study was twofold: first, to collect data from a normative population, and second, to use filters with defined bandwidths, which together envelop the visible spectrum.