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Color vision in attention-deficit/hyperactivity disorder: A pilot visual evoked potential study

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KEYWORDS
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Abstract
Background: Individuals with attention-deficit/hyperactivity disorder (ADHD) are reported to manifest visual problems (including ophthalmological and color perception, particularly for blue–yellow stimuli), but findings are inconsistent. Accordingly, this study investigated visual function and color perception in adolescents with ADHD using color Visual Evoked Potentials (cVEP), which provides an objective measure of color perception.
Method: Thirty-one adolescents (aged 13–18), 16 with a confirmed diagnosis of ADHD, and 15 healthy peers, matched for age, gender, and IQ participated in the study. All underwent an ophthalmological exam, as well as electrophysiological testing color Visual Evoked Potentials (cVEP), which measured the latency and amplitude of the neural P1 response to chromatic (blue–yellow, red–green) and achromatic stimuli.
Result: No intergroup differences were found in the ophthalmological exam. However, significantly larger P1 amplitude was found for blue and yellow stimuli, but not red/green or achromatic stimuli, in the ADHD group (particularly in the medicated group) compared to controls.
Conclusion: Larger amplitude in the P1 component for blue–yellow in the ADHD group compared to controls may account for the lack of difference in color perception tasks. We speculate that the larger amplitude for blue–yellow stimuli in early sensory processing (P1) might reflect a compensatory strategy for underlying problems including compromised retinal input of s-cones due to hypo-dopaminergic tone.

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PALABRAS CLAVE
TDAH;
adolescente;
déficit de visión del color;
potencial evocado visual

Visión del color en el trastorno de déficit de atención e hiperactividad: un estudio piloto de potenciales evocados visuales

Resumen
Antecedentes: Se ha reportado que las personas con trastorno de déficit de atención e hiperactividad (TDAH) manifiestan problemas visuales (incluyendo oftalmológicos y de color, particularmente para estímulos azul-amarillo), aunque los hallazgos son inconsistentes. El presente estudio investigó la función visual y la percepción del color en adolescentes con TDAH, utilizando potenciales evocados visuales (PEV), que aportan una medición objetiva de la percepción del color.
Métodos: Participaron en el estudio treinta y un adolescentes (de edades comprendidas entre 13 y 18 años): 16 con diagnóstico confirmado de TDAH y 15 individuos sanos, equiparados por edad, sexo e IQ. Todos ellos fueron sometidos a examen oftalmológico y a pruebas electrofisiológicas de PEV, que midieron la latencia y amplitud de la respuesta neuronal P1 a los estímulos cromáticos (azul-amarillo, rojo-verde) y acromáticos.
Resultados: No se hallaron diferencias entre los grupos en el examen oftalmológico. Sin embargo, se halló una amplitud significativamente mayor de P1 para los estímulos azul-amarillo, aunque no para los estímulos rojo/verde o acromáticos, en el grupo de TDAH (particularmente en el grupo medicado), en comparación a los controles.
Conclusión: La mayor amplitud en el componente P1 para azul-amarillo del grupo TDAH, en comparación a los controles, podría explicar la falta de diferencia en las tareas de percepción del color. Suponemos que la mayor amplitud para los estímulos azul-amarillo en el proceso sensorial temprano (P1) podría reflejar una estrategia compensatoria para los problemas subyacentes, incluyendo el input retiniano comprometido de los conos S debido al tono hipo-dopaminérgico.

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is one of the most frequently diagnosed childhood psychiatric disorders, with worldwide prevalence rates estimated at 5.3%.[1] However, despite the long history of research since its first medical description in 1775,[2] to date, it remains unclear what are the 'deficits' in ADHD. Current theories posit that executive function deficits account for ADHD symptoms. However, according to a substantial number of studies, ADHD is also associated with visual perceptual problems that cannot be explained by executive dysfunction (appendix A). ADHD is a neuro-developmental disorder which is associated with delayed cortical maturation in many regions, including the occipital cortex.[3,4] Specifically, color perception has been reported to be altered in ADHD population (appendix B). For instance, in our previous study, young adults with ADHD reported significantly more self-perceived visual difficulties in everyday tasks as well as poorer hue discrimination specifically for blue stimuli.[5] Furthermore, children with ADHD have been found to score poorly on clinical tests of blue–yellow color perception, but not red–green,[6,7] and showed decreased game performance in a virtual environment when important on-screen information was displayed predominantly in blue–yellow colors compared to performance with information displayed in red–green colors.[8] Finally, several studies report decreased speed in color processing in the ADHD population.[9,10] The possibility of color perception problems in ADHD is of clinical importance, given the extensive use of color in educational settings, as well as the frequent use of color stimuli in many of the standard neuropsychological tests used in the assessment for ADHD and related disorders (e.g. Color-Word Stroop Test, Wisconsin Card Sorting Test, A Quick Test of Cognitive Speed, Rapid Automatized Naming).

Color vision mechanisms, particularly the short-wavelength pathway, are particularly vulnerable to insult from toxins, and highly sensitive to CNS drugs and the neurotransmitter, such as dopamine. Accordingly, the ''retinal dopaminergic'' hypothesis of color vision[11] proposes that the dopamine deficiency in central nervous system (CNS) in ADHD population may induce a hypo-dopaminergic tone in the retina, which in turn would have deleterious effects on short-wavelength (S) cones. S-cones are sensitive to blue–yellow light wavelengths and to dopamine (as well as other neurochemical agents), and relatively scarce in number. Thus, the purported low dopaminergic tone in ADHD may have a specific effect on blue color perception. To our knowledge, so far, testing this hypothesis in the ADHD population has solely relied on clinical tests of color perception. Clinical vision tests have been criticized for their requirements for sustained attention and motor coordination, which are known to be impaired in ADHD.[12,13] Also these tests do not inform about mechanisms underlying poor performance on B–Y stimuli. In addition, most of these studies have focused on children with ADHD.[5–7]