Short Communication

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Investigating the Effect of Space Frequency Modulation of Visual Stimuli on the Visual Acuity of the Optic Cortex

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ABSTRACT

BACKGROUND AND OBJECTIVE: The choice of the response of the visual cortex to different space frequencies has been studied in several studies. The importance of the present study is to investigate the role of space frequency modulation in determining the magnitude of different neoplasms, and measure various types of myopia. The purpose of this study was to investigate the effect of modulation of visual acuity space frequencies on the response of the visual cortex in bipolar mode by magnetic resonance imaging.

METHODS: In an analytical study, 12 people (5 males and 7 females) participated in the study. It was decided that they were right-handed, had no specific disease (neurological and systemic) and had no refractive errors. The pupil size was measured by visual acuity; magnetic resonance imaging was performed using a Phillips MRI device with a magnitude 1.5 Tesla magnetic field. Since the duration of each test was 4 minutes (consisting of 8 blocks of 30 seconds). IRCT:2016021326538N2

FINDINGS: There was a significant relationship between refractive error and fuzzy state with diopter 1.00+ lens at mid-frequency (p=0.005) and high (p=0.03). Additionally, there was a refractive error between the refractive error and false positives with a diopter of 3.00+ lens at high space frequency (p=0.009). The variation in the number of activated vasks is significant only in the mid space frequency, and in comparison with the refractive error and artificially constructed near-diopter 1.00+ lens (p=0.026).

CONCLUSION: Considering the efficacy of optic optics due to proximity to the response of the visual cortex, the necessity of correcting any refractive errors in visual science studies and related studies, such as neuroscience studies, as well as the separation and separation of refractive errors from neurological factors affecting the cortex response, Becomes.

KEY WORDS: *Myopia, Visual Cortex, Visual Acuity.*

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Introduction

The effect of the physical parameters of visual stimuli on the response of the visual system has been widely studied and it has been determined that the physical parameters of visual stimuli such as color, shape, luminescence, contrast, spatial and temporal frequencies are effective on the response of the visual system (1- 5). Spatial and temporal frequencies contain the primary and main information of visual stimuli that are essential for processing images in the higher center of the visual system such as cortex. Various factors, including refractive errors, especially myopia, cause the uncomplete spatial frequency processing of visual stimuli in the cortex (5).

Myopia with increasing optical blur and subsequently reducing the quality of retina images create the changes in the cortex response (5). These changes can be recorded in psychophysical studies by increasing the visual acuity or reducing visual acuity threshold (6), reducing the contrast sensitivity function (7), and in recording the visible excited potential by increasing latency and reducing the amplitude component of the 100P of the VEP wave (8).

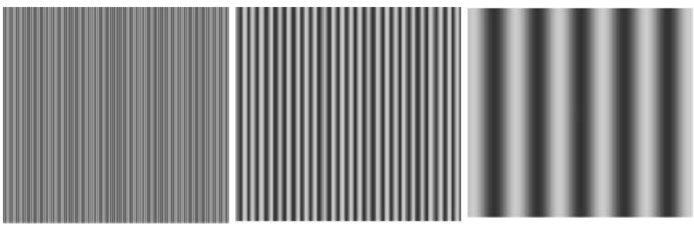
In these studies, it has been determined that myopia has significant effects on the outcome of visual examination and the overall response of the visual system. The severity of this condition is such that its effects on the response of the visual system cannot be ignored, and in most cases, myopia is considered as an interventive factor (5), and researchers have argued the need to use measures to minimize this state of affairs. On the other hand, it has been proven that the visual cortex, in addition to take effect from physical and optical factors, acts selectively toward some physical parameters of visual stimuli such as spatial frequencies, and so on (9). Mirzajani et al. in studying the effect of spatial and temporal modulation of visual stimuli on the activity of human visual cortex with the help of functional magnetic resonance imaging stated that the visual cortex shows a selective response to spatial and temporal frequencies (10). However, the effects of spatial frequencies of visual stimuli and refractive errors have not been studied at all. In existing studies, the effects of refractive errors have been studied solely and only at a constant and specific spatial or temporal frequency. Elbel et al., with the study of artificial myopia using a +8.00 diopter lens at a temporal frequency of 4 Hz and comparing with loss of refractive error, showed that myopia is effective on the cortex response, and reduces its response to the emmetropia (5). Mirzajani et al., in their study of artificial myopia using +1,00, +3,00, +5,00 diopter lens at a spatial frequency of 1.84 cycles in degree and 8 Hz, stated that the mean intensity of the BOLD signal and the number of activated voxel in artificial myopia condition shows an irregularly decreasing trend toward the emmetropia (11). Therefore, the aim of this study was to investigate the effect of the spatial frequencies modulation of visual stimuli on the response of the visual cortex in the myopia by fMRI.

Methods

This analytical study was approved after approval by the Ethics Committee of Ilam University of Medical Sciences with the code of 93212.2 A and the 2N2016021326538IRCT Clinical Trials Reg No, on 12 right-handed healthy volunteers (5 males and 7 females) aged 18-32 years (with the mean age of 23 ± 4 years). In this study, reversible vertical sinusoidal patterns with spatial frequencies of 0.4, 2 and 8 cycles per degree were used for activity mode. The visual stimuli were at a specific and stable distance from the volunteers (D=255 cm), which was equivalent to the distance between the eyes of the volunteers inside the scanner of the imaging apparatus and the projection screen that displayed the stimuli. The visual formed field on the screen in horizontal and vertical direction was 115 and 87 centimeters, respectively. With the help of Equation 1, the full viewing of the visual stimuli on the screen according to Equation 1 was 12.49 × 9.45 degrees. Equation 1:

$$L = \frac{2\pi D}{360}$$

Linear values are converted to angular values. Accordingly, the field of vision required by the volunteers to fully observe the visual stimuli on the screen was 9.49×9.95 degrees. Figure 1 shows examples of visual stimuli used in this study.



C B A

Figure1. Types of visual stimuli used in the study at various spatial frequencies: low spatial frequency (a), middle spatial frequency (b) and high spatial frequency (c).

Magnetic resonance imaging was performed using a Philips MRI device with a 1.5-Tesla magnetic field with a blood oxygen level dependent method using the echo planar technique in the Imaging Department of Rasoul-e-Akram Hospital. Since the duration of each test was 4 minutes (consisting of 8 blocks of 30 seconds), each functional volume was obtained within 3 seconds.

Thus, in each experiment, 80 functional volumes including 25 cross sections with a thickness of 4 mm were prepared parallel to the anterior-posterior line path. An echo gradient sequence with T2 weights was used with the following parameters. Right-handed patients with no specific disease (neurological and systemic) and no refractive errors were included and in the absence of cooperation and the presence of eye-related diseases, they were excluded. Confirmation of disease was carried out according to previous studies (10, 11). In this study, spatial frequency, artificial myopia, BOLD signal strength, and activated voxel count were studied.

After completion of functional and anatomical scans, the original data was stored in format of (Digital Imaging and Communication in Medicine=DICOM). In order to information process in the first place, data was converted to analytical formats with image processing soft wares. Then, in order to determine the effect of spatial frequency modulation of visual stimuli, the mean percentage of change in the intensity of the BOLD signal and the number of activated voxels induced by visual stimulation in volunteers participating in different dysfunctional conditions the ANOVA Repeated Measurement was used.

Results

In this study, the response of the visual cortex was performed in 12 volunteers (7 men and 5 women) with emmetropia (RE-25±25.0) aged 18-25 years (mean age of 23±4 years). In this study, the percentage of BOLD signal during low spatial frequency was not significantly correlated with any artificial myopia with absence of refractive error state.

However, there was a significant relationship between absence of refractive error and artificial myopia with diopter 1.00+ lens at mid spatial-frequency (p=0.005) and high spatial-frequency (p=0.03). In addition, there were no significant changes between refractive error and artificial myopia with 3.00+ diopter lens at high spatial frequency (p=0.009). Figure 2 shows functional images consistent with anatomical images of voluntary no. 12 during modulation spatial frequency in various modes of artificial myopia and emmetropia.

The results show that changes in the number of activated voxels are significant only during mid spatial frequency and in comparison with the absence of refractive error and artificial myopia with+1.00 diopter lens (p=0.026). While there were no significant statistical changes in other states. The diagram shows the variation in the number of activated voxels during modulation of spatial frequency in different amounts of artificial myopia in all participants in this study.

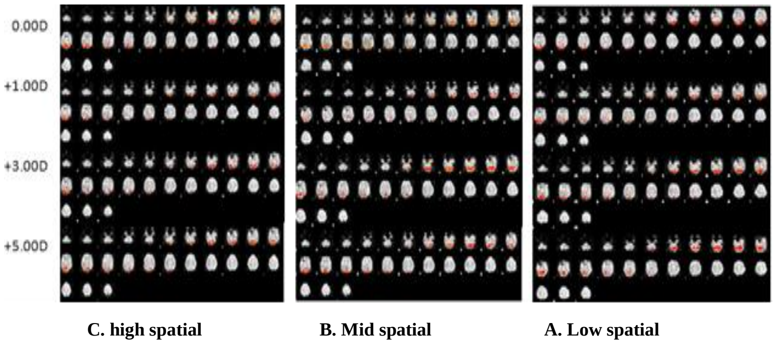


Figure2. Functional images of volunteer number 12 (female, 23 years old) conforming to anatomical images during modulation of spatial frequency in various states of artificial myopia and emmetropia

Discussion

The results of this study show that during spatial frequency modulation, the percentage of BOLD signal as well as the number of recorded voxels in all artificial myopia states is less than that emmetropia state. This difference in response is increased by increasing the spatial frequency, so that it increases with the increase in the level of myopia and is statistically significant, which indicates the effect of optical blur effects on the response of the visual cortex. The findings of this study are consistent with the results of psychophysical studies (6), excited vision potential record (8, 12), and magnetic resonance imaging (5). On the other hand, despite the decrease in the response of the visual cortex in different levels of myopia, the results do not show significant differences in different amount of myopia, which is not consistent with the results of some studies (6, 12). Regarding these results, fMRI seems to be unable to record gradual changes in artificial myopia. The results of this study show that during the modulation of spatial frequencies in an emmetropia state, with increasing spatial frequency, the recorded response to the visual cortex increases, so that the highest response is recorded at high spatial frequency. One of the possible reasons for this phenomenon is the more importance of spatial information at the HSF frequency in the final processing of visual images.

Visual stimuli consist of a wide range of tiny and large data that are processed by the visual system in the form of various spatial frequencies. High spatial frequencies contain details of visual images that are essential for processing in higher visual centers, and the elimination or reduction of this spatial frequency has significant effects on image perception. These changes are well documented by functional magnetic imaging parameters. The removal of high spatial frequencies caused by optical blur results in a significant decrease in the BOLD signal and the number of activated voxels in various states of artificial myopia. Therefore, the correction of any disrupting factor in retinal image quality, such as refractive errors, is necessary. Because functional magnetic resonance imaging is used in the study of neurological diseases (2), recognizing the effect of myopia and the severity and weakness of this effect on the spatial frequencies and differentiating these effects from neurological factors affecting the visual cortical performance is of great importance and can be very helpful in this regard. Based on the results, and given the effectiveness of myopia on the response of the visual cortex (5), the necessity of correcting any amount of refractive errors is fully felt, given the obvious effects on the perception of visual images. Also, due to the high sensitivity of the high spatial frequency to refractive errors, it is recommended that even in the case of fMRI studies that cannot be fully corrected, even this spatial frequency spectrum not to be used. The results of this study showed a decrease in the response of the visual cortex in different levels of myopia to the emmetropia state.

Despite the slight decrease in various levels of myopia, the results indicate the effectiveness of the myopia on the cortex response. Therefore, with regard to the effectiveness of optical blur due to the myopia to response of the visual cortex, the need to correct any refractive error in the studies of visual science and related studies, such as neuroscience studies, and the separation of the effects of refractive errors on neurological factors affecting the entire cortex response feels.

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