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The Relation Between Supramodal Processing and Visual Acuity Less Than 20/30 in 8- to 12-Year-Old Children

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ABSTRACT

Background: Optometric practice goes beyond the diagnosis and treatment of the different refractive conditions and eye diseases. It includes an evaluation of information processing skills that depend, in some way, on supramodal processing stability. This involves simultaneous and sequential or successive processing. Cerebral function allows for normal perception of what is being seen; any deficit may have repercussions in learning. The object of this study is to investigate the relationship between simultaneous and sequential or successive processing.

Methods: Forty-four children, ages 8 to 12 years, were divided into two groups based on visual acuity: ametropia and emmetropia. The Hand Movement Test, a sub-test of the Kauffman Assessment Battery for Children (KABC), and the Visual Organization Test (VOT) were performed by all participants.

Results: Simultaneous processing evaluated with the VOT did not show statistically significant differences ($p=0.07$). In contrast, the sequential or successive processing obtained by using the Hand Movement Test showed that the differences were statistically significant ($p<0.05$).

Conclusion: A deficit in visual acuity is not related to simultaneous processing but is related to sequential or successive processing.

Keywords: sequential and simultaneous processing, refractive error, visual acuity

Introduction

Childhood is the most important developmental stage; neurological and maturational bases of development are established.[1] During childhood, between 75% and 90% of children begin their learning using the visual system.[1] If there is a disruption in input or interpretation of information during development, this can cause a learning delay, affecting reading, writing, reasoning, or mathematical skills.[2-6]

Vision provides the most information to the brain regarding the shape, color, depth, lighting, spatial location, and direction[7] of the environment and other objects within the visual field.[8] Proper development requires that information coming to the brain is commensurate with the surrounding environment, particularly between 6 and 12 years.[9] This is considered to be the most flexible stage in human development[10] and is when the skills necessary for learning are established.

Throughout development, different optical elements influence dioptric power according to the amount of image defocus within the eye.[11] It is documented that the human eye at birth is 3.00 diopters hyperopic, which is reduced to emmetropia by approximately 6 years of age.[12] Optical components like the cornea and crystalline lens can cause changes in vision as axial length increases so that they can continue to focus clear images on the retina.[13,14] However, this process may be affected by multiple factors, including genetics, visual deprivation, mechanical pressure on the eyeball, food, and health. In some cases, the ametropia decreases, especially in those with medium or high levels. In other cases, it seems to be more stable or increases during school age, impacting the development of learning skills.[15,16]

The supramodal process (SP) introduces the application of the link between the temporal and spatial processes for learning to read. This includes the simultaneous process (SPsim), where the stimuli perceived are fully inspected or available globally at some point in time and sequence. In the sequential process (SPsec), the information is distributed temporally and is presented serially.[17,18] There are tests available for testing both types that allow us to estimate some deficit.

The Visual Organization Test (VOT) requires the use of organizational and re-visualization skills. First published in 1958, it is a tool to evaluate neurological imbalances in adolescents and adults.

The VOT consists of 30 images. Each image is a simple object such as a cup, a cane, a key, or an apple. The objects have been cut into two, three, or four parts and separated like in a puzzle. The patient reports what the object would be if the pieces were put together. The test is easy to apply and takes only a few minutes to perform. One point is assigned for each

Figure 1. *Patient sample distribution according to age.*

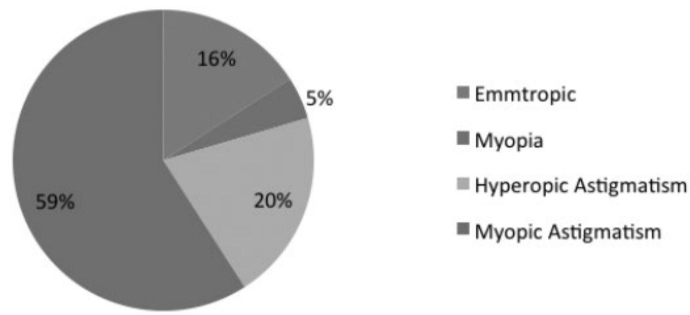

Figure 2. *Classification according to refractive condition.*

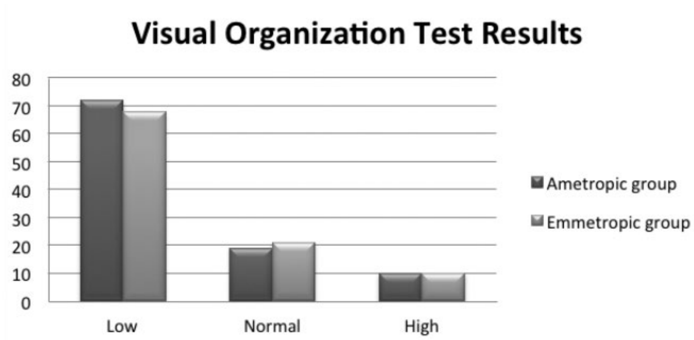

Figure 3. *VOT results for the simultaneous processing according to the obtained percentage.*

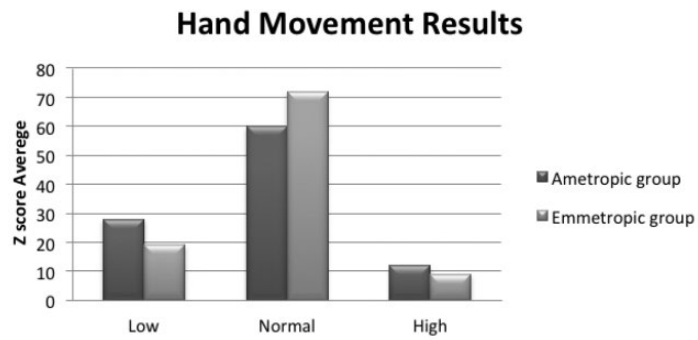

Figure 4. *Hand Movement Test for sequential memory according to the percentage obtained results. *statistical significance*

correct answer. The total score is compared to the mean and standard deviation expected for the patient's age, obtaining the Z score and the percentile.

For sequential processing we work with the Hand Movement test (HM), which allows an evaluation of simultaneous or sequential processing skills independent of language and visual motor integration skills. The examiner makes a set of hand movements with a specific sequence using the palm or fist and at a certain speed of movement per second. There are 21 possible combinations, so the patient must pay attention to the movement made and repeat it in the same sequence. If the child makes a mistake in the sequence of movements, the examiner must decrease the number of movements and record the number of hits obtained. One point is granted for each correct answer. The score is compared with the mean and standard deviation expected for the patient's age, and the Z score and percentile are determined.

Difficulty with simultaneous or sequential processing is not always detected in school-age children even though they can have repercussions on academic performance.[19] For this reason, it is believed that decreased visual acuity impacts the quality of the information needed for efficient simultaneous and sequential processing.

MATERIALS AND METHODS

A descriptive observational study was performed with a convenience sample of children between 8 and 12 years old at an elementary school in Aguascalientes, México. The sample included 22 ametropic and 22 emmetropic patients, of whom 50% were girls and 50% were boys in each group. The inclusion criteria for the ametropic group included: 1) visual acuity worse than or equal to 20/30, 2) an intraocular difference in visual acuity equal to or less than 3 lines. Patients with strabismus, psychomotor alterations such as ataxia and apraxia, and those unable to comprehend the testing were excluded.

Visual acuity was determined with the Snellen chart for distance (6 meters) and near (40 cm), monocularly and binocularly. The type of the ametropia was determined with static retinoscopy and trial lenses. Sequential processing was evaluated with the HM and simultaneous processing with the VOT. The results obtained from both tests were converted into percentiles and compared with the expected values for the patient's age. The results were classified as low, normal, or high depending on the percentile.

RESULTS

The subjects' ages were between 8 and 12 years old, with a mean of 10 and SD +/-1.16 years (Figure 1). The distribution by refractive conditions was 59% myopic astigmatism, 20% hyperopic astigmatism, 16% emmetropia, and 5% myopia (Figure 2).

The results of the VOT and HM were classified as low, normal, or high according to the percentile. For the ametropic group on the VOT, 71% were considered low results, 19% normal, and 10% high. In comparison, for the emmetropic group, 69% were low, 21% normal, and 10% high (Figure 3).

Evaluation by student t-test showed no statistical significance (p=0.07).

The HM test in the ametropic group showed 28% low, 60% normal, and 12% high. In the emmetropic group, 19% obtained low values, 72% were normal, and 9% were high values. Statistical significance was found for the low score group ($p<0.05$) but not the normal and high groups (Figure 4).

DISCUSSION

Simultaneous and sequential processing are cerebral functions which measure the capacity for integration and the skill to resolve problems whose elements are presented in successive form.[18]

For simultaneous processing, we did not find statistical significance. This suggests that this type of processing is not related to visual acuity. Simultaneous processing requires the development of skills including figure/ground discrimination, visual memory, and visual closure. We evaluated children with and without ametropia; those with poorer visual acuity had lower results on the VOT test versus those with excellent visual acuity. This can be explained in terms better clarity of vision leading to better information processing and sensory integration with the environment. The exact relationship should be researched further in a longitudinal formatted study.

The sequential or successive processing determined by the HM suggests that inefficient visual acuity can be related to a sequential processing deficit. Therefore the need for vision correction or subpar visual acuity may influence integration capacity and the ability to follow instructions.

Parents often bring their children for a visual evaluation because of the academic difficulties initially attributed to poor vision, when in fact the problem could be related to cerebral processing.[6] Therefore, it is important to evaluate information processing or perceptual abilities. Koller[6] states that visual processing is a cerebral function that allows normal perception of what is being seen. Eye care professionals must consider that even if the patient has 20/20 vision, this does not rule out a processing disorder.

Koller et al.[20] explored the relationship between visual skills and verbal learning. He demonstrated a positive association: in children with vision worse than 20/50, there was a verbal disorder involving a deficiency in reasoning, visual memory, and visual-spatial perception. In this study, we cannot validate this relationship since neither of the tests performed contained a verbal component. Further evaluation of this relationship should be considered, and test selection should include ones with a possible verbal interaction.

Lin et al.[21] conducted a study using the VOT in healthy Chinese children and those with mental disorders. A significant difference was demonstrated in the two populations. As refractive error was not reported, we are unable to comment on the impact it may have had on the results.

This study shows that sequential processing is lower in the children with ametropia. Since we used a test that required that the children follow a hand movement, a possible reason for our finding is explained by Ungerleider and Mishkin. They state that the dorsal pathway is an occipitoparietal network that lies between early visual cortex and specialized cortical structures involved in visually-guided action and spatial working memory. The type of visual information required by these processes is very general. For example, an observer's hand and the target can appear in any retinotopic position, and the occipitoparietal network must still create an accurate map of their relative positions to guide the action effectively. The need to represent these types of relationships leads to the formation of coordinate systems and general frames of reference. Thus, the dorsal pathway specializes in capturing arbitrary and dynamic spatiotemporal relationships between multiple items.[22] We postulate that the blurry visual information entering the eye with a refractive error could not integrate correctly, explaining this result.

CONCLUSION

Decreased visual acuity is not related to simultaneous processing but is related to successive or sequential processing. The evaluation of information processing skills allows the optometrist to diagnose the presence of deficits that may have repercussions in the learning process and academic potential. Further investigation on the impact of correction of ametropia on tests of sequential processing is warranted.

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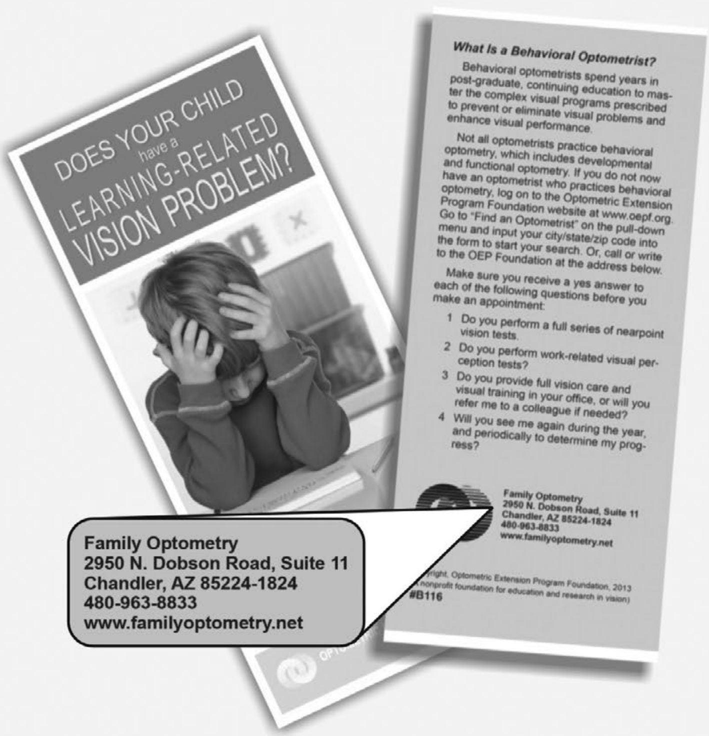

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