

Visual perceptual skills in school children aged 7 to 12 years with refractive amblyopia

Habilidades visoperceptuales en niños escolarizados de 7 a 12 años con ambliopía refractiva

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ABSTRACT

Visual perception is a skill that involves a series of related sub-skills, which interact with each other in order to efficiently analyze, integrate, and synthesize visual information. *General objective:* To determine the status of visual perceptual skills in school children aged 7 to 12 years with refractive amblyopia, residents of Bogotá. *Materials and methods:* A descriptive observational study was developed; the sample was obtained by visual screening of the students of the selected age group—complete examination, including cycloplegia, of the students with possible positive amblyopia in screening—and by applying TVPS-3 to the children with confirmed diagnosis of amblyopia. *Results:* The visual perceptual skills of visual closure, figure-ground, form constancy, and spatial relationships were more frequently below normal values. *Conclusions:* The study found that some of the visual perceptual skills in the amblyopic patients of the sample were below the values considered normal.

Keywords: amblyopia, visual perceptual skills, test of visual perceptual skills

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RESUMEN

La percepción visual es una habilidad que involucra una serie de subhabilidades relacionadas, que interactúan entre sí para analizar, integrar y sintetizar la información visual de manera eficiente. *Objetivo general:* determinar el estado de las habilidades visoperceptuales en niños escolarizados entre 7 y 12 años con ambliopía refractiva, residentes de Bogotá. *Materiales y métodos:* se desarrolló un estudio observacional descriptivo; así mismo, se contribuyó en la obtención de la muestra al efectuar tamizaje visual a los estudiantes del grupo de edad seleccionado (examen completo, incluida cicloplejia, a los estudiantes positivos posibles ambliopes en el tamizaje) y al aplicar la prueba TVPS-3 a los niños con diagnóstico de ambliopía. *Resultados:* las habilidades visoperceptuales de cierre visual, figura fondo, constancia de forma y relaciones espaciales se presentaron con mayor frecuencia por debajo de los valores normales. *Conclusiones:* se encontró que algunas de las habilidades visoperceptuales en los pacientes ambliopes de la muestra estaban por debajo de los valores considerados normales.

Palabras clave: ambliopía, habilidades visoperceptuales, test de habilidades visoperceptuales.

INTRODUCTION

This article is the result of participating in the macro-project entitled *Effects of refractive amblyopia on the development of the linguistic skills of reading and writing in school children aged 7 to 12 years in public and private schools in Bogotá (Colombia)*. This macro-project was developed by professors of the Faculty of Optometry at the Universidad de La Salle, with funding from the institution.

Generally, studies of amblyopic patients focus on refractive states, ocular motility, and stereopsis; there is, however, a limited number of research on the visual perceptual state, which is responsible for interpreting visual information.

According to the World Health Organization (1), there are 7.5 million school-aged children, who have some kind of visual impairment, but only 25% of them show symptoms. As it is well known, the development and learning of cognitive and motor activities occurs at school age. Garzia (2) estimates that 20% of the children who receive special education services experience reading difficulties and have poor processing of visual information. Borsting (3) incorporates the motor, auditory, language, and attention systems in addition to the non-motor aspects of visual perception and cognition that involve higher brain functions.

According to Ahissar and Hochstein (4), learning is a top-down guided process, which begins at high-level areas of the visual system, and when these do not suffice, progresses backwards to the input levels, which have a better signal-to-noise ratio. Van Waelvelde et al. (5) studied the association between visual perceptual deficit and motor impairment in children with developmental coordination disorder; in effect, they demonstrated an association between visual perceptual deficits and motor tasks, which are a fundamental part of child development.

Delgado (6), in his article entitled "Detection of visual disorders," evidences the need to develop programs for the management of effective tools that diagnose visual alterations in primary health care, and solve this problem.

It is important to evaluate visual perceptual skills as part of the pediatric eye examination for the diagnosis and management of amblyopic patients, since optometrists often are the first to evaluate children with difficulties at school.

VISUAL PERCEPTION

Some of the skills involved in the organization and processing of visual information are visual perceptual skills, which belong to the concept of

visual perception (3) and are essential in cognitive development (7).

Visual perception, according to Groffman (8), is the central process of knowledge acquisition, in which information is located and extracted from the external environment. In this way, it refers to the process of receiving visual information through sensory impulses and its subsequent translation into meaning, based on a previous experience with the environment (9). In the same sense, Jaramillo (10) affirms that perception is a cognitive process achieved during the child's maturation; however, previous experience is required, which allows a better interpretation of the facts perceived on successive occasions.

The visual perceptual skill is composed of, or better, it involves a series of related sub-skills and abilities, which interact with each other to efficiently analyze, integrate, and synthesize visual information (11,12).

When visual perception does not develop properly, important visual alterations occur; this is the case of significant refractive defects with unilateral or bilateral reduction of visual acuity, caused by inadequate visual stimulation of the brain during the critical period of visual development (6). Merchán and Henao (13) point out that perception is organized in perceptual systems, which are responsible for the process of searching and acquiring information.

A *perceptual skill* is the ability to identify pertinent tasks, specific features of a sensory selection. Perceptual skills determine the analysis level of sensory information; these are divided into (12):

- *Visual discrimination*: Ability to discriminate dominant features of objects, for example, the ability to discriminate position, shape, contour, and color.
- *Spatial relationship*: Ability to perceive the relationship of objects in relation to themselves

or to other objects (upside down or rotated figures).

- *Visual memory*: Ability to recognize a stimulus item after a short time interval.
- *Figure-ground*: Ability to identify an object within a complex background or surrounded by figures.
- *Visual closure*: Ability to identify a whole figure when only fragments are presented.

TEST OF VISUAL PERCEPTUAL SKILLS

The Test of Visual Perceptual Skills (TVPS-3), as a reference model, evaluates the visual perceptual skills of an individual without involving motor requirements. It was designed for both diagnostic and research purposes. It allows reliably measuring some aspects of visual perception in school-aged children of up to 18 years (12). This test uses seven subtests that begin with two sample items, followed by 16 items arranged from least to greatest difficulty.

The seven subtests are organized according to difficulty level: they begin with visual discrimination and end with visual closure. They evaluate the following skills: visual discrimination, visual memory, spatial relationship, form constancy, sequential memory, figure-ground, and visual enclosure.

During the test, children respond verbally, starting with the number below the figure they choose. They can also point to it or use some other kind of language. The examiner must record the responses in a form. Each answer is qualified as 1. The score types used to indicate performance on TVPS-3 are those of clinical interest: scaled scores (usually used to report the results of individual subtests), standard scores (used to report composite or net results), percentile ranks, and age equivalents. All these score types allow any response given by a child on the test to be rela-

tively compared with the scores of other children of similar age.

Raw scores (correct answers) are recorded at the end of each subtest. Subtest raw scores are then converted into scaled scores (scaled values). The net score and optional indexes are derived from the sum of scaled scores: these are reported as standard scores and percentile ranks, respectively (12). Age equivalents are also provided. Standard scores are between 131 and 89 points, according to the TVPS-3 manual.

AMBLYOPIA

Amblyopia is defined as a condition of low or reduced visual acuity, not correctable by refractive means and not attributable to pathological abnormalities or disorders of the afferent visual pathway. The word *amblyopia* literally means “opacity of vision.” The best-corrected visual acuity is less than 20/30 (6/9); this is considered a descriptive criterion for amblyopia. Amblyopia with visual acuity from 20/30 to 20/70 is usually mild (superficial); it is moderate when visual acuity ranges from 20/80 to 20/120, and marked or deep when visual acuity is less than 20/120 (14).

Daw (15) states that there may be a loss of connections or a distortion or a rearrangement of connections within the visual cortex. What happens varies depending on the deficit, given that compensation in the central nervous system is specific to the optic or motor problem that causes amblyopia. In some cases, there may even be a distortion of vision without loss of visual acuity.

MATERIALS AND METHODS

Study design: Observational descriptive.

Population: School children aged 7 to 12 years with refractive amblyopia, residents of Bogotá.

Sample: At convenience, 23 school children aged 7 to 12 years with refractive amblyopia.

Inclusion criteria: Children aged 7 to 12 years who have refractive amblyopia.

Exclusion criteria: Children who present with strabismic or deprivation amblyopia, as well as with any type of ocular fundus pathology, nystagmus or diagnosis of any type of neurological, systemic, or psychological disease or disability condition.

PROCEDURE AND TECHNIQUES

In the first place, visual screening was conducted in students of the selected age group; subsequently, informed consent forms were left at schools so that the students' parents or legal guardians fill them out. Then, a complete examination, including cycloplegia, was performed on students with possible positive amblyopia at screening and eyeglasses were given to those who required them with a check-up one month after they started to use them; finally, TVPS-3 was applied to children with confirmed amblyopia diagnosis. The procedure to develop each test complied with the protocol of the Ibero-American Epidemiological Network in Visual and Ocular Health (Reisvo).

The data obtained were entered in an Excel database, from which they were transferred to statistical packages (SPSS and STATA). First, descriptive statistics were determined for the group, and, subsequently, statistical correlation tests were performed. Finally, the discriminant analysis of each factor was carried out.

RESULTS

Eighty-one patients aged 7 to 12 years were evaluated; 23 of them were diagnosed with refractive amblyopia: 34.78% were girls—average age: 9.48 (± 1.77)—and 65.21% were boys—average age: 9.14 (± 1.62).

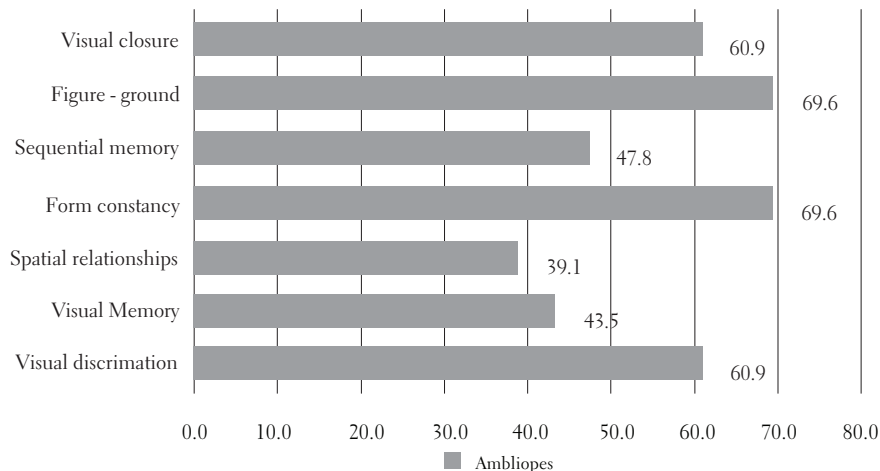


FIGURE 1. Frequency of amblyopic children (percentage) with a below-average score in TVPS-3

In TVPS-3 (Figure 1), visual closure (CLO), figure-ground (FGR), form constancy (CON), and visual discrimination (DIS) had a high frequency of children (> 60%), which were rated as below average.

Figure 1 shows that four skills (CLO, FGR, CON, and DIS) had below-average scores.

The discriminant variables of TVPS-3 had a canonical correlation of 0.48 in the ability to recognize a significant reduction in test performance for amblyopic children. It can be observed that the Wilks' Lambda is moderately high (0.77, where 1 is high), indicating low variability of values between the subtests (discriminant variables of TVPS-3) performed in amblyopic students.

Table 1 evidences that CLO, FGR, and spatial relationships (SPA) had a moderate high influence (considering their proximity to 1), regarding the performance of amblyopic children in the test.

DISCUSSION

In 2008, Merchán (16) published a study comparing TVPS-3 scores in children aged 4 to 7 years. During the process, two groups of patients were formed, one with high ametropias and the other

with very low ametropias; both groups had normal motor status. The study found that there were no major differences in the test scores between the two groups.

TABLE 1. Structure of canonical discriminant functions for TVPS-3

DISCRIMINANT VARIABLES	FUNCTION 1
Visual closure (CLO)	0.795
Figure-ground (FGR)	0.708
Spatial relationships (SPA)	0.617
Sequential memory (SEQ)	0.442
Form constancy (CON)	0.360
Visual discrimination (DIS)	0.335
Visual memory (MEM)	0.192

When comparing the above with data from this research, differences are present, since it was found that in the amblyopic patients of the sample, four of the seven skills evaluated had below-average frequency, which is indicative of the great importance of early diagnosis and correction of refractive anomalies present during development.

Pino and Bravo (14) conducted a study with 105 children from Chilean primary schools (average age: 6 years), aiming to evaluate the relationship of visual-orthographic recognition, perception, and visual memory with initial reading. To the effect, they applied tests that evaluated the following

elements: the child's approach to the graphic components of writing, awareness of printed materials, pre-reading and pre-writing, visual perception, attention, concentration, and visual memory. Based on the results obtained, they concluded that the ability to encode, store, and retrieve information from visual memory is an indispensable condition for the recognition of words. The test they used to measure visual perception, concentration, and memory had a success percentage of 56.92%, while the section that evaluated visual memory had a success percentage of 46.1%.

A comparison of these results with those of this study found that visual memory was the skill with the best score in amblyopic children, and sequential memory had a moderate to good score. Thus, it is possible to affirm that these results correspond to each other in a certain way, despite the age difference and the refractive status of patients, since the skills with the best performance were the same in both studies.

Durán et al. (17) studied the prevalence of dysfunctions in saccadic movements, visual perceptual skills, and visual motor integration in emmetropic children between 6 and 7 years of age. In relation to visual perception skills, they reported that the number of patients with below-average results was very low, compared with the sample total (37 out of a total of 117). On the other hand, the present research evidenced the opposite: a large part of the studied sample had values below the average in four of the seven skills evaluated in the test.

Bermúdez et al. (18) conducted a subject review in order to establish the relationship between (refractive and strabismic) amblyopia and the reading process. They analyzed components such as visual motor and visual perceptual conditions, and concluded that amblyopia significantly affects them. This was evidenced in the results of the present study, in which about 60% of the children in the sample had below-average perceptual skills.

Henaó and Camacho (19) studied the prevalence of visual motor and visual perceptual dysfunctions in children aged 5 to 9 years, who were clinically emmetropic or had visual acuity of 20/20. The work was developed in three groups of patients, according to city districts in Bogotá. They found that visual perceptual dysfunctions had a high prevalence in two of the three districts studied (68.4 and 47.7%). The authors suggest that acquiring these dysfunctions does not depend only on the visual optic system, but other factors may be involved too, such as the socioeconomic stratum. Although it was not among the objectives of the present study, the sample was mainly from socioeconomic strata 1 to 3.

Visual perceptual skills can be significantly affected due to the loss of the position of the observed image, as mentioned by Moseley and Fielder (20). Hess (21) studied how an amblyopic person perceives visual stimuli presented to him and how he processes them at the cortical level to translate them, subsequently, into an image. After analyzing different factors, they concluded that due to the loss of the position of the observed image as well as the loss of contrast sensitivity, the image of an object perceived by an amblyopic patient is different from what is thought, since said perception is made up of dots superimposed on each other, which form the final image. They also relate all this to Vernier visual acuity, which refers to directionality, that is, to the knowledge of where an object is located with respect to another. This may explain the below-average scores of the amblyopic children in the sample in CLO, FGR, CON, and DIS.

Daw (15) states that one of the causes for a significant alteration of visual perception skills may be an imprecise final image formed by the connections between the retina and cerebral cortex. This is the case of anisometropic amblyopia, in which the image in one eye is out of focus most of the time, which degrades the image on the retina. As a result, connections between retina and cor-

tex do not form a topographic map as accurately as they do in a visually healthy person, which could influence visual perceptual skills such as CON and DIS.

CONCLUSIONS

The analysis of the results of this study concluded that the status of visual perceptual skills in the patients of the sample was “below average,” specifically the FGR, CLO, CON, and DIS skills. These findings are consistent with different studies that evidence findings such as spatial distortion, temporal instability, and crowding phenomenon in amblyopic eyes (22,23), which could explain the perceptual alterations found.

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