Age-related changes in children's threshold exposure duration for recognition of test objects

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Key words: children, threshold exposure duration for recognition of test objects

Background: *Timely detection of an object in the visual field is of primary importance to adults and children.*

Purpose: To investigate threshold exposure duration for recognition of test objects (TEDRTO) in normal vision children of various age groups.

Materials and Methods: *Four hundred and sixteen children (832 eyes; age, 5 to 17 years) with a refraction within the age norm (emmetropia or hyperopia of up to 1.0 D) were included into the study and underwent assessment of TEDRTO with a special electronic apparatus. The apparatus was used to expose a test object (an illuminated Landolt's ring subtending 8 minutes of arc) against a black background.*

Results: *In children of 5 to 6 years, 7 to 10 years, 11 to 14 years, and 15 to 16 years, binocular threshold exposure durations for recognition of the white test object subtending 8 minutes of arc were found to be 2.1 ± 1.3 ms, 1.4 ± 0.5 ms, 1.1 ± 0.3 ms and 1.1 ± 0.3 ms, respectively.*

Conclusions: *The results obtained can be used as reference values while investigating threshold exposure durations for recognition of test objects in various disorders of the visual system.*

Introduction

Timely detection of an object in the visual field (possibly, a view of approaching danger), as well as recognition and prompt response to the appearance of this object are of primary importance to any human being or living creature. The findings of such important parameters of visual acuity as expositional visual acuity (EVA) (i.e., visual acuity at various test object exposure durations) and Threshold Exposure Duration for Recognition of Test Objects (TEDRTO) (minimum time required for recognition of the test object subtending a specified visual angle) have been previously reported [1-8]. In addition, the latter index has been assessed in individuals with various refractive statuses, strabismus, and amblyopia [9, 10]. Investigation of age-related changes in TEDRTO in pre-school and school children with normal visual acuity is deemed to be important.

The study purpose was to investigate threshold exposure duration for recognition of test objects in children of various age groups with a visual acuity of not less than 1.0, and with a refraction within the age norm.

Materials and Methods

Four hundred and sixteen children of 5 to 17 years (5 to 7 years, 79 children; 7 to 10 years, 79 children; 11 to 14 years, 171 children; 15 to 17 years, 87 children) were included into the study. Therefore, all child age groups were well represented. Other inclusion criteria were good ophthalmic health, no refracting medium pathology or fundus pathology, and a refractive error within the normal range for the child's age (emmetropia or hyperopia of up to 1.0 D).

The study children underwent visual acuity assessment, refractometry, examination of eye position and eye movements, and evaluation of media and fundus. Threshold Exposure Duration for Recognition of Test Objects was assessed with a special electronic apparatus. The apparatus was used to expose a test object (an illuminated Landolt's ring with a gap randomly at one of the eight positions; ring luminance, 25 candela/mm2) against a black background, with the test object presented for 1 ms to 15 ms, and 1-ms gaps between presentations. If the child failed to identify the target gap direction with the minimum exposure time, the time was increased until he could identify the direction fairly reliably, with not less than 5 correct identifications in succession. The test object had an angular size of 8 minutes of arc. Therefore, its image was projected onto the central fovea; the average angular size of the central fovea has been reported to be 1.3 degrees of arc [11]. The distance from the apparatus to the child under examination was 5 m. Both monocular and binocular TEDRTO examinations were performed in the morning hours under photopic conditions.

Due to the features of the data obtained for statistical analyses, we used the Kruskal−Wallis test, which is a non-parametric equivalent of analysis of variance, and extends the Mann-Whitney U test when there are k > 2 independent samples.

Results

Table 1 presents the results of statistical analyses of monocular and binocular TEDRTO in children of the study using Kruskal–Wallis H test.

Table 2 presents the results of multiple comparisons of p-values between groups (monocular and binocular TEDRTO in children).

The tables presented demonstrate that the children of age group 1 required statistically significantly more time for binocular recognition of white test objects than the children of other age groups. In addition, the mean TEDRTO value in age group 2 was greater than those in the older age groups. No difference in TEDRTO values between group 3 and group 4 was observed (P =1.0).

Similar relationships were observed for the TEDRTO related to monocular recognition of test objects. The older the children were, the less time their visual system required for the recognition of the test object presented.

The results obtained can be presented graphically (Fig. 1). The figure clearly demonstrates that, as the age group number increases from 1 to 4, the average rank of the group decreases, which corresponds to a decrease in the time required for recognition of the test object. A similar relationship is seen for the use of a parametric statistical method (Table 3). The mean TEDRTO value decreases with age, from 2.2±1.3 ms in children of 5 to 6 years, to 1.1 ± 0.3 ms in children of 11 to 14 years and in children of 15 to 17 years. This relationship between mean TEDRTO value and age group is also shown in Fig. 2.

Therefore, TEDRTO variability diminishes with maturation of the visual system: by the age of 11 years, TEDRTO values become stable, with no further changes.

Conclusions

In children of 5 to 6 years, 7 to 10 years, 11 to 14 years, and 15 to 16 years, with a visual acuity of not less than 1.0, and with refraction within the age norm, binocular threshold exposure durations for recognition of the white test object subtending 8 minutes of arc were found to be 2.1 ± 1.3 ms, 1.4 ± 0.5 ms, 1.1 ± 0.3 ms and 1.1 ± 0.3 ms, respectively. The results obtained can be used as reference values while investigating threshold exposure durations for recognition of test objects in various disorders of the visual system.

Table 1. Results of statistical analyses of binocular and monocular Threshold Exposure Durations for Recognition of Test Objects (TEDRTO) in children using Kruskal–Wallis H test

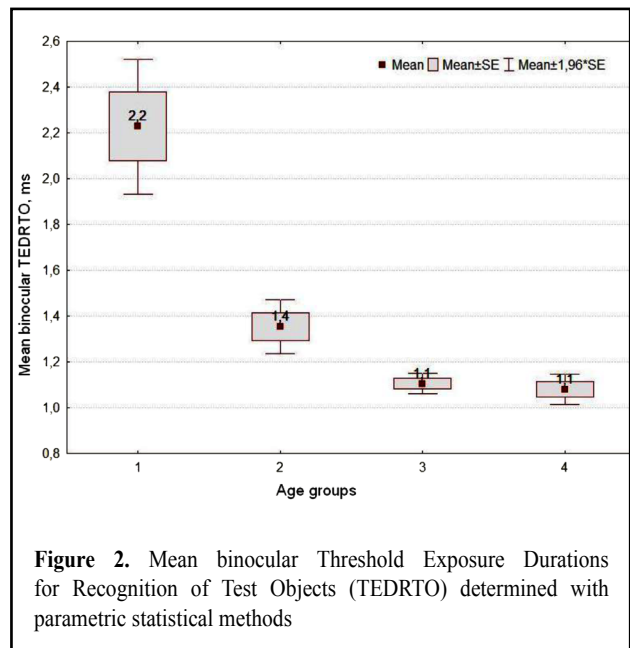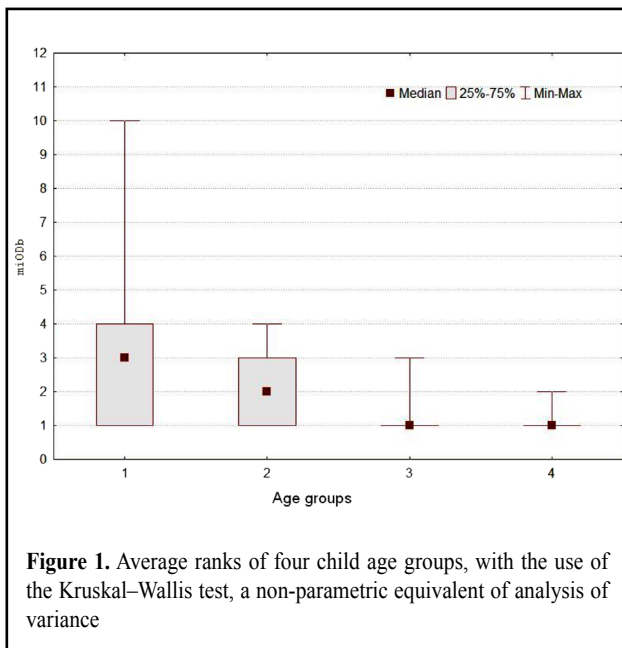| Binocular/ Monocular	Group number	Number of children	Rank sum	Average rank
Binocular	1	79	23514.5	297.65
	2	79	17640.5	223.30
	3	171	30586.5	178.87
	4	87	14994.5	172.35
Monocular	1	79	24095.5	305.01
	2	79	18951.0	239.89
	3	171	29323.5	171.48
	4	87	14366.0	165.13
Children, total		416		

Table 2. Multiple intergroup comparisons of p-values (monocular and binocular Threshold Exposure Durations for Recognition of Test Objects (TEDRTO) in children)

Binocular/ Monocular	Group number	Average group rank (R)			
		1- R:297.65	2 - R:223.30	3 - R:178.87	4 - R:172.35
Binocular	1		0,000610	0,000000	0,000000
	2	0.000610		0.039605	0.038401
	3	0.000000	0.039605		1.000000
	4	0.000000	0.038401	1.000000	
Monocular	Group number	Average group rank (R)			
		1 - R:305.01	2 - R:239.89	3- R:171.48	4 - R:165.13
	1		0.003984	0.000000	0.000000
	2	0.003984		0.000173	0.000379
	3	0.000000	0.000173		1.000000
	4	0.000000	0.000379	1.000000	

Table 3. Mean binocular Threshold Exposure Durations for Recognition of Test Objects (TEDRTO) determined with parametric statistical methods

Group number	Number of children	M, seconds	σ	V (%)
1	79	2.2	1.3	59.0
2	79	1.4	0.5	35.7
3	171	1.1	0.3	27.2
4	87	1.1	0.3	27.2
Total mean value		1.4	0.8	

Note: M, mean binocular Threshold Exposure Duration for Recognition of Test Objects (TEDRTO); σ, standard deviation; V, variability factor

Figure 1. Average ranks of four child age groups, with the use of the Kruskal–Wallis test, a non-parametric equivalent of analysis of variance

Figure 2. Mean binocular Threshold Exposure Durations for Recognition of Test Objects (TEDRTO) determined with parametric statistical methods

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