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The Importance of Measuring Dynamic Visual Acuity

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A B S T R A C T

In their everyday life, people interact with different objects, static as well as those in motion. However, dynamic acuity is rarely checked in medical examinations, even those preceding the issue of driving license. In order for driving to be safe, good eyesight or good correction with visual aids is imperative. Beside good eyesight, drivers also have to have good reflexes and short reaction span. The aim of this study was to compare dynamic and static visual acuity in order to observe how they vary among individuals. Twenty female and male participants, 65 years of age, took part in the study and the comparison was made with the results provided by 20 20-year old participants. Dynamic acuity was tested using the Landolt-ring optotype which was simulating movement velocity of 72 km/h. T-test demonstrated the presence of a statistically significant difference between dynamic and static acuity among the participants from 62 to 68 years of age ($t=15.852$; $df=39$; $p<0.01$). Within the same group, dynamic acuity (mean=0.887; std. deviation=0.297) proved to be significantly worse than static acuity (mean=1.40; std. deviation=0.317). By comparing the results measured within the older group of participants with those measured in the younger group, it was shown that there exists a statistically significant difference ($t=0.275$; $df=58$; $p<0,05$) between the older and younger group in their dynamic binocular acuity with correction. Younger participants had better dynamic binocular acuity with correction (mean=1.063; std. deviation =0.259) than the older participants (mean=0.884; std. deviation=0.298). The differences between dynamic and static acuity and its degradation in the older age groups have to be taken into account when issuing driving licenses. The future of research lies within the study of correlation between the age and acuity in order that the results can be applied in practice.

***Key words**: dynamic and static visual acuity; good eyesight; good correction; visual aids; reflexes and time reaction*

Introduction

The aim of this study was to investigate the correlation of measured visual acuity (VA) obtained with static and dynamic measuring techniques, as well as to compare the results gathered for the two age groups. In everyday life, we are constantly in motion (playing sports, while driving, etc,) or we encounter moving objects, which is why it seems very interesting and important to research the correlation between dynamic and static acuity and how the dynamics of objects influence our ability to see. Static acuity is used mostly when observing static objects, or their details.

Examining static acuity implies the study performed while the subjects are not moving. Measuring static acuity in this study was conducted with the standard method, using Landolt-rings optotypes projected on the screen. On the other hand, dynamic acuity is used in situations when we look at moving objects (or details), as well as in cases when we move and the observed object does not.

As opposed to that of static acuity, measurement of dynamic acuity is not standardized. The Landolt-ring movement with the velocity of 72 km/h was used in this study. A special test was developed for this purpose, and its results were sorted by the age of the test participants. The possibility of employing such tests in driving license vision testing should be further explored.

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Method

The study included a test group consisting of 40 subjects (20 male, 20 female) in the age range of 62 to 68 years (mean 64.2 years SD ± 1.99), as well as a group of 20 subjects (10 male, 10 female) in the age range of 20 to 22 years (mean 21.1 years SD ± 0.76). The measurement of dynamic acuity was conducted with the help of a computer program constructed in Adobe Flash Player. The test sign that was presented on a LCD screen consisted of a Landolt-ring construction (Figure 1) shown in eight different positions and in the size corresponding the visual acuity of VA=3.0 to VA=0.1 in steps of 0.1. The Landolt-ring construction was created with the use of Formula 1., for calculating the width of the Landolt-ring opening (d), as well as its total height and width (D), individually for every height of acuity, Formula 2., was used for calculating the angle of the Landolt-ring opening (ε °) for every individual distance from which the ring is viewed. By incorporating that result into Formula 3., the height of acuity (V) was calculated.

Formula for construction of the Landolt-ring:

$$d = \tan \varepsilon^{\circ} \times a\,[\mathrm{m}]$$

$$D = 5 \times d\,[m]$$

for which it sands: d – height of the Landolt-ring opening; ε – opening angle of the Landolt-ring for a specific acuity height; D – height and width of the Landolt-ring

Formula for calculating the angle of the Landolt-ring opening:

$$\tan \varepsilon = \frac{d[m]}{a[m]} \times 60'$$

for which it stands: d – width of the Landolt-ring opening; a – distance from which the Landolt-ring is observed

Formula for calculating the height of acuity (V)

$$V = \frac{1}{\varepsilon}$$

for which it stands: V – height of acuity

Calculation of d and D values necessary for the construction of Landolt-ring, were made for the acuities in Table 1.

The starting point is that, if we move by the speed of 72 km/h per second, we cover the distance of 20 m, per two seconds 40 m, per three seconds 60 m, etc. Taking into account that the starting point used for the test is 6 m, what follows is that the distance taken into calculation will be enhanced by 6 m. Namely, the test subject is standing still, while the Landolt-rings simulate movement. When corelation of mentioned data was made with the data concerning the size of Landolt-rings and according acuities, results were gathered of how fast and with what dynamics the sizes of Landolt-rings have to change in order to simulate movement of 72 km/h. In more detail, if the starting point is that the d of Landolt-rings for the acuity of 0.1 for the distance of 6 m is d=1.745 cm, and D=8.73, formulas 2 and 3 are used in order to gather

TABLE 1
CALCULATION OF LANDOLT-RINGS CONSTRUCTING SIZES WITH ACCORDING ACUITY FOR THE DISTANCE OF 6 m DISPLAYED IN METRES AND CENTIMETRES

Acuity	d [m]	5d=D [m]	d [cm]	5d=D [cm]
0.08	0.021817	0.109084	2.181671	10.908356
0.10	0.017453	0.087267	1.745334	8.726671
0.125	0.013963	0.069813	1.396266	6.981330
0.16	0.010908	0.054542	1.090832	5.454160
0.20	0.008727	0.043633	0.872665	4.363326
0.25	0.006981	0.034907	0.698132	3.490660
0.32	0.005454	0.027271	0.545416	2.727078
0.40	0.004363	0.021817	0.436332	2.181662
0.50	0.003491	0.017453	0.349066	1.745329
0.63	0.002770	0.013852	0.277036	1.385182
0.70	0.002493	0.012467	0.249333	1.246664
0.80	0.002182	0.010908	0.218166	1.090831
1.00	0.001745	0.008727	0.174533	0.872665
1.10	0.001587	0.007933	0.158666	0.793331
1.116	0.001564	0.007820	0.156392	0.781958
1.125	0.001551	0.007757	0.155140	0.775702
1.25	0.001396	0.006981	0.139626	0.698132
1.30	0.001343	0.006713	0.134256	0.671280
1.45	0.001204	0.006018	0.120368	0.601838
1.60	0.001091	0.005454	0.109083	0.545415
1.75	0.000997	0.004987	0.099733	0.498666
1.80	0.000970	0.004848	0.096963	0.484814
1.90	0.000919	0.004593	0.091859	0.459297
2.00	0.000873	0.004363	0.087266	0.436332
2.10	0.000831	0.004156	0.083111	0.415555
2.20	0.000793	0.003967	0.079333	0.396666
2.45	0.000712	0.003562	0.071238	0.356190
2.60	0.000671	0.003356	0.067128	0.335640
2.80	0.000623	0.003117	0.062333	0.311666
3.00	0.000582	0.002909	0.058178	0.290888
3.10	0.000563	0.002815	0.056301	0.281505

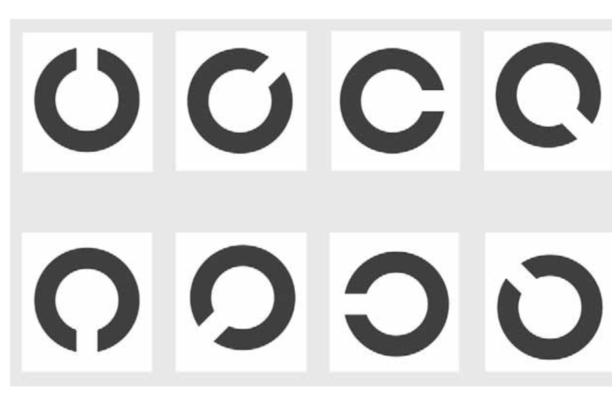

Fig. 1. Landolt-ring in eight positions.

TABLE 2
CALCULATION OF SIZE CHANGING DYNAMICS OF THE LANDOLT-RINGS

Distance [m]	d [m]	D [m]	d [cm]	D [cm]	Neccesary acuity
6	0.017453	0.087267	1.745334	8.726671	0.100001
26	0.017453	0.087267	1.745334	8.726671	0.433340
46	0.017453	0.087267	1.745334	8.726671	0.766679
66	0.017453	0.087267	1.745334	8.726671	1.100085
86	0.017453	0.087267	1.745334	8.726671	1.433573

data of the neccesary acuity for a specific distance. Results are shown in Table 2.

It is evident from Table 2 that enhancement of the distance for further 20 m from the starting point requires 0.33 better acuity. Concordantly, one second requires the size changing dynamics of Landolt-rings for 0.33 of the acuity. For example, in one second, the size of Landolt-ring has to change from the acuity height of 0.4 to the acuity height of 0.1. That is, the diameter of 2.18 cm and the opening size of 0.44 cm has to change to the diameter of 10.91 cm and the opening size of 2.18 cm.

The Landolt-ring dynamically increased simulating approaching velocity of 72 km/h (=45 mph). Every measurement started with the size of Landolt-ring corresponding the acuity VA=3.0 (=6/2), and its size increased in the same orientation to VA=0.1 (=6/60). At the moment when the subject recognized the direction of the Landolt-ring opening, he/she would press the keybord key, which caused the animation to stop. The measure of visual acuity was then displayed at the bottom of the LCD screen, as seen in Figure 2. The subject then had to state the correct orientation of the Landolt-ring opening. The test was repeated five times (only correct answers were taken into account) for mono and binocular vision. Results were compared to the static visual acuities measured by the same Landolt test displayed on the LCD screen.

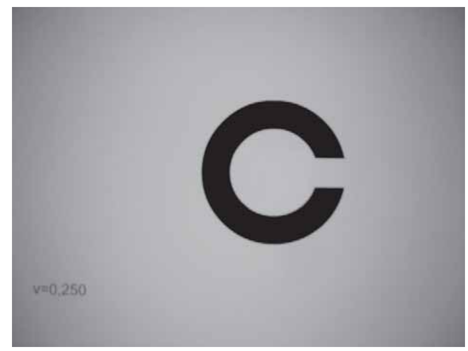

Fig. 2. Landolt-ring optotype with the mark of visual acuity.

Results

The study was conducted on 40 subjects, 20 female and 20 male. In the course of the measurements, following information about the subjects have been gathered:

- Number of participants in the study
- Year of birth of the subjects
- Heights of Vsc monocular
- Height of Vsc binocular
- Height of Vcc monocular measured by the static method
- Height of Vcc binocular measured by the static method
- Height of Vcc monocular measured by the dynamic method
- Height of Vcc binocular measured by the dynamic method
- Profession (career) of the subjects

All gathered data is displayed in Table 3. The study has been conducted on a group of 40 subjects, 20 out of which were female, and 20 male.

As stated, all subjects had their static and dynamic binocular acuity measured, and their average values have been displayed in Table 4.

After the normality of distribution was checked and validated for all the variables, t-test has was conducted for all dependent groups in order to examine whether a difference exists between static and dynamic acuity. T--test indicated that there is a statistically significant difference between dynamic and static acuity in the subjects ($t=15.852$; $df=39$; $p<0.01$), Dynamic acuity (mean =0.887; std. deviation=0.297) proved to be significantly worse than static acuity (mean=1.40; std. deviation= 0.317), (Figure 3).

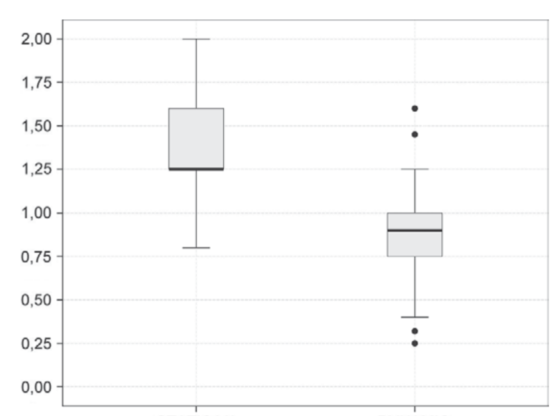

Fig. 3. Measured static and dynamic values of visual acuity.

It was also examined whether there is a difference between male and female subjects and the t-test has been conducted for individual groups of participants. Results showed that there is no statistically significant difference between male and female subjects in neither dynamic ($t=1.142$; $df=38$; $p>0.05$) nor static acuity ($t=1.307$; $df=38$; $p>0.05$).

The results indicate that there is no significant difference in visual acuity measured monocularly as opposed to that measured in binocular conditions, Study subjects whose static acuity was equal or bigger than 1.25 have achieved better results in dynamic measurings (a small decrease of visual acuity), as shown in Figure 4.

TABLE 3
DISPLAY OF THE NUMBER OF SUBJECTS, THEIR YEAR OF BIRTH, ACUITY AND PROFESSIONS

Ord num	Sex	Age	STATIC ACUITY	Vsc mono d.o.	Vsc mono l.o.	Vsc bino	Vcc mono d.o.	Vcc mono l.o.	Vcc bino
1.	F	66		0.10	0.10	0.12	1.60	1.60	1.60
2.	M	67		0.50	0.50	0.50	1.00	1.00	1.25
3.	F	64		0.40	0.32	0.50	1.60	1.60	1.60
4.	M	65		0.20	0.40	0.40	0.80	1.25	1.25
5.	F	62		0.50	0.80	0.80	1.25	1.60	1.60
6.	M	62		0.70	0.80	1.00	1.60	1.60	2.00
7.	F	63		1.00	1.00	1.00	1.60	1.60	2.00
8.	F	68		0.60	0.80	0.80	1.00	1.00	1.25
9.	F	69		0.80	1.00	1.00	1.00	1.25	1.25
10.	F	63		0.10	0.08	0.10	0.80	0.80	1.00
11.	M	64		0.63	0.80	0.80	1.25	1.60	1.60
12.	M	67		0.40	0.50	0.50	1.25	1.25	1.60
13.	F	63		0.80	0.63	1.00	1.25	1.00	1.25
14.	F	66		0.10	0.08	0.10	1.60	1.60	1.25
15.	M	62		0.40	0.50	0.50	1.25	1.60	1.60
16.	M	65		0.63	0.80	1.00	1.25	1.60	2.00
17.	M	63		0.50	0.63	0.63	1.25	1.25	1.25
18.	M	65		0.10	0.10	0.10	1.60	1.60	2.00
19.	M	65		0.50	0.50	0.50	1.00	1.00	1.25
20.	F	62		0.08	0.08	0.08	0.70	0.70	0.80
21.	F	65		0.20	0.40	0.40	0.80	1.25	1.25
22.	F	62		0.50	0.80	0.80	1.00	1.25	1.25
23.	M	62		0.30	0.80	1.00	1.25	1.25	1.25
24.	F	62		1.00	1.00	1.00	1.60	1.60	1.60
25.	F	64		0.60	0.80	0.80	1.00	1.00	1.25
26.	M	62		1.00	1.00	1.00	1.25	1.25	1.25
27.	F	62		0.10	0.08	0.10	0.80	0.80	0.80
28.	M	64		0.63	0.63	0.80	1.25	1.25	1.25
29.	M	63		0.40	0.50	0.50	1.25	1.25	1.25
30.	F	66		0.80	0.63	1.00	1.25	1.00	1.25
31.	M	63		0.10	0.08	0.10	1.60	1.25	1.60
32.	M	66		0.40	0.50	0.50	1.25	1.60	1.60
33.	M	63		0.63	0.80	0.80	1.25	1.60	2.00
34.	M	63		0.50	0.63	0.63	1.25	1.25	1.25
35.	M	62		0.08	0.08	0.08	0.80	0.80	0.80
36.	F	64		0.32	0.40	0.40	0.80	1.25	1.25
37.	F	67		0.50	0.80	0.80	1.00	1.25	1.25
38.	M	62		0.30	0.80	1.00	1.25	1.25	1.25
39.	F	65		1.00	1.00	1.00	1.60	1.60	1.60
40.	F	66		0.60	0.80	0.80	1.00	1.00	1.25

DYNAMIC ACUITY	Vcc mono d.o.	Vcc mono l.o.	Vcc bino	PROFESSION
	0.80	0.80	1.00	Writer
	0.63	0.63	0.80	Economist
	0.70	0.70	0.80	Retired person (F)
	0.40	0.80	0.80	Driver
	0.80	1.00	1.00	Housewife
	1.00	1.00	1.25	Driver
	1.60	1.60	1.60	Economist
	0.70	0.70	0.80	Housewife
	0.63	0.70	0.70	Accountant
	0.25	0.25	0.40	Housewife
	1.00	1.00	1.116	Driver
	0.63	0.80	1.00	Agronomist
	0.40	0.32	0.50	Economist (F)
	0.70	0.40	0.70	Housewife
	0.63	0.70	1.00	Dentist
	0.70	0.80	1.25	Driver
	0.63	0.70	0.80	Architect
	1.25	1.25	1.25	Retired person
	0.63	0.63	0.80	Hunter
	0.16	0.20	0.32	PPT technician
	0.63	0.80	1.00	Cleaning lady
	0.80	1.00	1.00	Saleswoman
	1.00	1.00	1.00	Economist
	1.45	1.45	1.45	Retired person (F)
	0.80	0.80	0.80	Professor (F)
	0.63	0.70	0.70	Mariner
	0.25	0.16	0.25	Accountant
	1.00	1.00	1.116	Professor (F)
	0.63	0.80	1.00	Driver
	0.40	0.32	0.50	Professor (F)
	0.70	0.32	0.70	Economist
	0.63	0.70	1.00	Economist
	0.70	0.80	1.10	Architect
	0.63	0.70	0.80	Repairman of technical devices
	0.40	0.32	0.32	Dental technician
	0.63	0.70	0.80	Cleaning lady
	0.80	1.00	1.00	Retired person (F)
	1.00	1.00	1.00	Economist
	1.125	1.125	1.25	Retired person (F)
	0.70	0.70	0.80	Retired person (F)

Furthermore, a comparison of results obtained by measuring static and dynamic acuity was conducted between the younger group of test participants and the results of the older group. The oldest participant's year of birth is 1943, while the youngest participant was born in 1992. The average value of the participants' year of birth is 1962 (mean=1962.17; std. deviation=20.558). That is, 50 years of age. The subjects' static binocular acuity with and without correction was measured, as well as their dynamic acuity with correction. Results are displayed in Table 5.

Calculated average values and deviation measures for mentioned acuities and years of birth can be found in Table 6.

Correlation matrix displayed in Table 7., shows that there is a statistically significant positive correlation be-

TABLE 4
DESCRIPTIVE DATA FOR DYNAMIC AND STATIC ACUITY

	Number of subjects	Minimal value	Maximum value	Arithmetic mean (average)	Standard deviation
Static acuity	40	0.80	2.00	1.40	0.317
Dynamic acuity	40	0.25	1.60	0.887	0.297

TABLE 5
OVERVIEW OF THE NUMBER OF TEST SUBJECTS, THEIR YEAR OF BIRTH, ACUITY AND PROFESSION

Ordin. num.	Sex	Age	STATIC ACUITY	Vsc mono d.o.	Vsc mono l.o.	Vsc bino	Vcc mono d.o.	Vcc mono l.o.	Vcc bino
1.	F	20		0.40	0.40	0.40	1.60	1.60	2.00
2.	F	20		0.60	0.60	0.60	1.20	1.20	1.25
3.	M	22		0.08	0.08	0.08	1.00	1.00	1.25
4.	M	21		0.20	0.40	0.40	1.00	1.25	1.25
5.	F	20		0.60	0.60	0.60	1.25	1.25	1.25
6.	F	22		0.70	0.70	0.80	1.60	1.60	2.00
7.	F	22		1.00	1.00	1.00	1.60	1.60	2.00
8.	M	21		0.80	0.80	0.80	1.00	1.00	1.00
9.	M	21		0.80	1.25	1.25	1.25	1.60	1.60
10.	M	21		0.25	0.10	0.25	1.00	1.25	1.25
11.	F	20		0.80	0.63	0.80	1.60	1.60	1.60
12.	F	22		0.63	0.50	0.63	1.25	1.25	1.25
13.	F	22		0.80	0.80	1.00	1.25	1.00	1.25
14.	M	22		0.08	0.08	0.10	1.25	1.25	1.25
15.	M	21		0.80	0.63	0.80	1.60	1.25	1.60
16.	F	21		0.63	0.80	1.00	1.60	1.60	1.60
17.	F	21		0.50	0.63	0.63	1.25	1.25	1.25
18.	M	22		0.50	0.50	0.50	1.60	1.60	2.00
19.	M	21		0.50	0.50	0.50	1.25	1.25	1.25
20.	M	21		0.40	0.50	0.50	1.25	1.25	1.60

DYNAMIC ACUITY	Vcc mono d.o.	Vcc mono l.o.	Vcc bino	PROFESSION
	1.60	1.20	1.20	Pupil (F)
	1.00	0.80	0.80	Pupil (F)
	1.00	1.00	1.00	Student
	1.00	0.80	0.80	Student
	1.00	1.00	1.00	Pupil (F)
	1.60	1.60	1.60	Student (F)
	1.60	1.60	1.60	Student (F)
	0.80	0.70	0.80	Student
	1.25	1.25	1.25	Student
	1.00	1.00	0.80	Student
	1.25	1.00	1.250	Pupil (F)
	1.00	1.00	1.00	Student (F)
	1.00	0.80	0.80	Student (F)
	1.25	1.00	1.00	Student
	1.00	1.00	1.00	Student
	1.25	1.25	1.25	Pupil (F)
	0.63	0.70	0.80	Student (F)
	1.60	1.25	1.25	Student
	1.00	0.80	0.80	Student
	1.25	1.25	1.25	Student

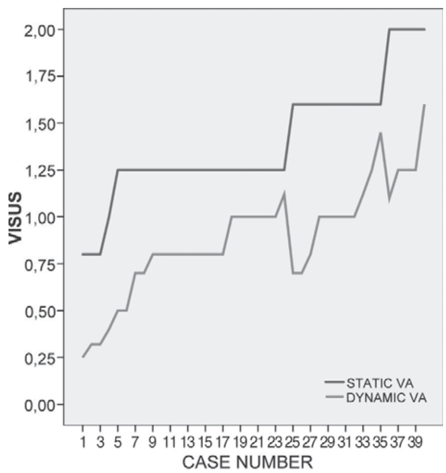

Fig. 4. Overview of visual acuity changes in individual subjects.

tween all provided types of acuity, as well as that there is a statistically significant positive correlation between the year of birth and dynamic acuity with correction (r= 0.227; p<0.05). This result indicates that the younger the person, the better dynamic acuity (with correction).

It is also important to state that there is no statistically significant correlation between sex and acuity, that is both men and women have approximately same height of acuity.

After the normality of distribution was validated, t-test affirmed that there is a statistically significant difference between static binocular acuity with correction and static binocular acuity without correction (t=16.250; df=59; p<0.01). As was expected, correction provides better acuity (mean=1.413; std. deviation=0.316), as opposed to the state without correction (mean=0.619; std. deviation=0.329).

TABLE 6
MINIMAL AND MAXIMUM VALUES, ARITHMETIC MEAN AND STANDARD DEVIATION FOR YEAR OF BIRTH, STATIC BINOCULAR ACUITIES WITH AND WITHOUT CORRECTION (VSC_BINO AND VCC_BINO) AND FOR DINAMIC BINOCULAR ACUITY WITH CORRECTION (DYN_VCC_BINO)

	Descriptive Statistics				
	N	Minimum	Maximum	$\overline{X}$	Std, Deviation
Age	60	65	22	50	20,558
vsc_bino	60	0.080	1.250	0.61933	0.329050
vcc_bino	60	0.800	2.000	1.41333	0.316478
dyn_vcc_bino	60	0.250	1.600	0.94370	0.295991

TABLE 7
CORRELATION MATRIX OF ALL VARIABLES – SEX, YEAR OF BIRTH, DYNAMIC BINOCULAR ACUITY WITH CORRECTION (DYN_VCC_BINO) AND STATIC BINOCULAR ACUITY WITH AND WITHOUT CORRECTION (VSC-BINO AND VCC-BINO)

		Correlations				
		dyn_vcc_bino	vsc_bino	vcc_bino	SEX	Year of birth
dyn_vcc_bino	Pearson Correlation	1	0.435**	0.824**	0.022	0.277*
	Sig. (2-tailed)		0.001	0.000	0.865	0.032
	N	60	60	60	60	60
vsc_bino	Pearson Correlation	0.435**	1	0.313*	–0.163	0.027
	Sig. (2-tailed)	0.001		0.015	0.212	0.839
	N	60	60	60	60	60
vcc_bino	Pearson Correlation	0.824**	0.313*	1	0.084	0.131
	Sig. (2-tailed)	0.000	0.015		0.525	0.319
	N	60	60	60	60	60
Sex	Pearson Correlation	0.022	–0.163	0.084	1	–0.015
	Sig. (2-tailed)	0.865	0.212	0.525		0.909
	N	60	60	60	60	60
Year of birth	Pearson Correlation	0.277*	0.027	0.131	–0.015	1
	Sig. (2-tailed)	0.032	0.839	0.319	0.909	
	N	60	60	60	60	60

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).

Another t-test was made in order to affirm whether there exists a statistical difference between dynamic and static binocular acuity,

After it was determined that all conditions for parametric tests were satisfied t-test showed that there is a statistically significant difference between dynamic and static (in both cases, corrected) binocular acuity (t= 19.935; df=59; p<0.01). Dynamic binocular acuity with correction is lower, that is decreased (mean=0.944; std. deviation=0.296) than static binocular acuity with correction (mean=1.414; std. deviation=0.316).

Finally, additional t-test analyses were conducted in order to affirm the existance and nature of acuity differences regarding age. Since the test participants, according to their age, were grouped in two groups, that is, two extremes (older and younger, as seen in Figure 5), such extremized groups were compared in the analysis.

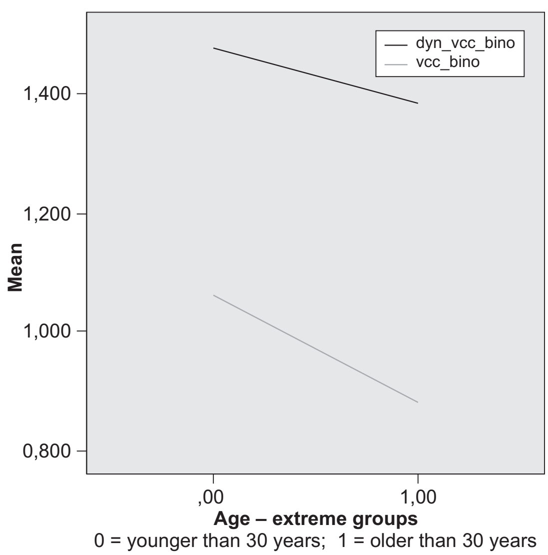

Fig. 5. Dynamic acuity regarding age.

Average values and measures of distribution of three different acuities regarding different age groups are displayed in Table 8: older test participants (group 1 – from 22 years of age; age ≥ 22) and younger test participants (group 2 – younger then 22 years of age). According to results from Table 8., t-tests comparing acuities by groups were made. Results are displayed in Table 9.

The Leven test of equality of variances is not significant and we can conclude that the variance is equal (homogenous) for all acuity types by groups formed by age.

T-test showed that there is no statistically significant difference in static binocular acuity with correction (t= 1.069; df=58; p>0.05) and without correction (t=0.209; df=59; p>0.05) between the two groups of participants (older and younger group). However, it was shown that there is a statistically significant difference (t=2.275; df=58; p<0.05) between the older and younger group regarding dynamic binocular acuity with correction. Younger test participants have better dynamic binocular acuity with correction (mean=1.063; std. deviation=0.259) then the older test participants (mean=0.884; std. deviation=0.298), (Figures 6 and 7).

Discussion

A number of studies analyzing measuring of dynamic visual acuity (Burg 1967, Kent et al., 1995, Hopkins, 1993–2001) showed that dynamic acuity declines with age or progression of eye disease. It was concluded that evaluation of dynamic visual acuity was especially relevant in drivers. This study was deployed in order to accentuate, while measuring dynamic visual acuity where the test was in axial motion, the time of subjects' reaction while the visual stimulus approaches. The basis of every reaction is a reflex arch consisting of 5 components:

1. Sensory organ or stimulus receiver, receiving stimulus;
2. Afferent neuron transmitting incurring stimulus from the receptor to the synapse in the form of an impulse moving by the speed of 100 m/s;
3. A synapse or a reflex nerve system transmitting the signal between the afferent and efferent neuron;
4. Efferent neuron is a motor neuron transmitting signals from the synapse to the effector;
5. Effector is a muscle or some other organ,

TABLE 8
ARITHMETIC MEANS AND STANDARD VARIATIONS OF DYNAMIC BINOCULAR ACUITY WITH CORRECTION (DYN_VCC_BINO) AND STATIC BINOCULAR ACUITY WITH OR WITHOUT CORRECTION (VCC_BINO AND VSC_BINO) WITH REGARD TO THE GROUPS OF TEST PARTICIPANTS DISTRIBUTED BY AGE (GROUPS G1 AND G2)

	Group Statistics				
	Age	N	$\overline{X}$	Std. Deviation	Std. Error Mean
dyn_vcc_bino	g1 ≥ 22	20	1.06250	0.258983	0.057910
	g2 < 22	40	0.88430	0.298340	0.047172
vsc_bino	g1 ≥ 22	20	0.63200	0.307513	0.068762
	g2 < 22	40	0.61300	0.342938	0.054223
vcc_bino	g1 ≥ 22	20	1.47500	0.317266	0.070943
	g2 < 22	40	1.38250	0.315528	0.049889

TABLE 9
RESULTS OF LEVEN'S TEST OF EQUALITY OF VARIANCES AND T-TEST FOR THREE DIFFERENT TYPES OF ACUITY IN TWO GROUPS OF TEST PARTICIPANTS GROUPED BY THEIR AGE

			Equal variances assumed		
			dyn_vcc_bino	vsc_bino	vcc_bino
Levene's Test for Equality of Variances		F	0.188	1.630	0.180
		Sig.	0.667	0.207	0.673
t-test for Equality of Means		t	2.275	0.209	1.069
		df	58	58	58
		Sig. (2-tailed)	0.027	0.835	0.290
		Mean Difference	0.178200	0.019000	0.092500
		Std. Error Difference	0.078336	0.090853	0.086567
	95% Confidence Interval of the Difference	Lower	0.021393	–0.162863	–0.080783
		Upper	0.335007	0.200863	0.265783

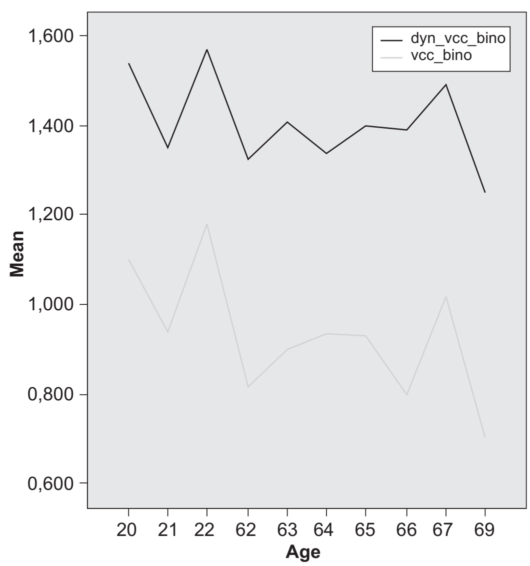

Fig. 6. Arithmetic mean comparison of dynamic and static acuity regarding age.

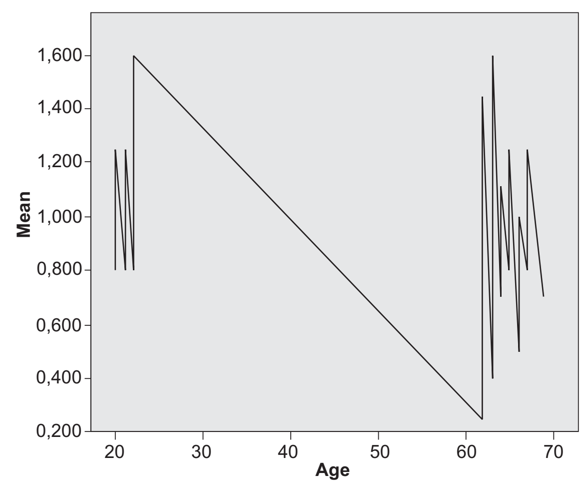

Fig. 7. Dynamic binocular acuity regarding age.

The contact between the efferent neuron and the muscle is defined as a motor board behaving functionally as a synapse (peripheral synapse). Action potential of the motor board spreads through the muscle cells and conditions contraction mechanism activation. Reflex time is the time of transmission from the stimulus to the response.

It includes:

1. Time of receptor stimulus latency,
2. Time of impulse transmission between receptor and synapse (afferent conduction),
3. Time of synaptic transmission,
4. Time of impulse conduct from the synapse to the effector,
5. Time of stimulus effector latency,

Latent reaction time is the time that elapses from the moment the organs were exposed to the stimulus until the first measurable electric reaction in the stimulated organ. According to C. Woodworth (1938), time of reaction to light is between 150 and 225 msc, and the average is around 180 msc. Considering the type of stimulus, the speed of reaction to visual, auditory and tactile stimuli can be differentiated. Reaction time is different for different stimuli: for example, visual signal reaction lasts longer than acoustic signal reaction because of different length of time necessary for the signal to turn into nerve impulses. That time span represents the time interval elapsing from the impulse triggering to the start of the willing reaction, and is therefore a direct indicator of the development level of reaction speed. Reaction time is highly genetically determined and can only be marginally improved with practice. Regarding a simple reaction, only 10–20% improvement is possible, 30% when it comes to reaction of choice. In his report »On the speed of mental processes« published in Acta Psychologica and

Attention and performance II (W. G. Koster, Ed., 1969)[7]. Donders states that »Duration of individual mental activities determines the reaction time difference between less complex and more complex mental activities«[8]. There are however still not enough realizations about the relation between reaction times and individual mental efficiency.

In this study, we were interested in sensory properties of the subjects' stimuli, that is, the abilities when the subject is focused on receiving the stimulus and the muscular ability of the stimulus, when the subject's attention is focused on performing the move. More precisely, the time of the willing reaction is structured from the time when the receptor forms the impulse (stimulus information), the time it takes for the impulse to transmit to the cerebral cortex, time it takes for the stimulus content to be processed, time it takes to constitute the response order for the stimulus, the time of transmitting the impulse to the effectors, and finally the time necessary to develop the effectory response. Starting point for the individual component analysis time, that is the stages of the process of running reactions of different complexities, is the time of simple sensorimotor reaction, where the subject performs a particular movement (presses a key, starts a lever) with maximum speed as a response to a signal known in advance[5]. That is a time of every reaction that includes only one signal, known in advance, and only one predetermined response. The time reaction also depends on the individual characteristics of the subject (such as sex, age, etc.), experiment conditions, actual state of the subject (focus on the task, fatigue, alcohol and pharmacological agents effects), etc.

For the needs of this study, speed of reaction based on the time elapsed since, for example, the moment when there is no sign displayed on the screen until the moment when a sign big enough for the subject to recognize can be defined. Let's call that time A. Then, since the author of the simulation program is familiar with how many milliseconds pass from the appearance of Landolt-ring sized acuity 3.0, until the moment the subject presses the key in sign of recognition, let's call that time time B. If we subtract time A from time B, we can calculate the reaction time.

Subjects participating in this study had relatively good visual acuity and no participant had eyesight problems, thanks to which consistent results were obtained. Measurements were conducted in controlled conditions, and the optotype contrast was equal and consistent. Because of the strong light intensity, no further adjustment on the side of the subjects was necessary.

In the future, it would be desirable to use this test for testing eyesight when obtaining driving license. It should be emphasized that dynamic visual acuity examination is difficult to perform in classic exam rooms since it requires special devices for presenting moving targets. The visual display of the unit used in this study is increasingly becoming the instrument for presenting optotypes and it requires only a software modification for presentation of approaching objects and a trigger. The mode of measuring presented in this study should be additionally investigated and expanded, that is, various conditions appearing in »real«, everyday life that influence perception of the moving target (such as dark conditions, changing optotype contrast, various difficulties with visual-motor functions and adjustment processes during measurements) should also be taken into account. Another issue that should be emphasized is the mesopic vision, where 27% of the drivers share the same pathological result[9].

The relation between measured visual acuity under static and dynamic conditions is mostly in accordance with results of other authors (W, Benson and Milton A., 1968) who tested subjects of the same age. Although using different instruments and methods. Research related to the influence of visual motor response (Whitney, D., 2008; Sherback, M., 2010) explains the significant decline in visual acuity when it is measured dynamically.

Conclusion

For majority of adults, the ability to conduct motorized vehicles is a prerequisite of a normal everyday life and an important aspect of one's autonomy, with emphasis on professional drivers. Despite of the fact, not enough stress is placed on examining visual acuity. What rises is the idea of standardizing the rules and laws concerning the level of visual acuity to be tested in standardized dynamic tests when obtaining driving licenses. Furthermore, repeated periodic testing would ensure detection of drivers with potentially dangerous level of visual acuity, and would serve as a reminder to the need of wearing glasses during driving. Public informing of the drivers concerning consequences of poor visual acuity during driving would also contribute to raising awareness of the importance of good visual acuity.

By means of statistical analysis, this study demonstrated that there is a difference between static and dynamic acuity. Dynamic binocular acuity is worse than static binocular acuity, in cases of using correction when measuring both types of acuity. The importance of this discovery lies in the fact that it demonstrates the importance of checking both types of acuity in medical examinations. Results corroborate that good static acuity does not necessarily guarantee good dynamic acuity.

Furthermore, the study showed that dynamic acuity decreases with age, while static acuity remains the same. Above result indicates that dynamic acuity decreases with old age and that it is necessary to check it through regular medical examinations, especially through physical examinations preceding driver's license renewal. Namely, it is quite probable that older people have slower reflexes and therefore need longer reaction time which may influence the results achieved in measuring dynamic acuity.

Results indicate that, in simulated driving speed of 72 km/h, response time to visual stimuli causes a decrease in measured visual acuity due to hidden variations in visual motor response. There is no significant difference in visual acuity measured dynamically between monocular and binocular viewing. Subjects who had visual acuity equal or higher than VA=1.25 achieved better results in dynamic measurements.

Testing and measuring of dynamic visual acuity as conducted in this study would be suitable for measurements in standardized procedures of driving license issuing. Since the visual acuity and response time are instantly measured via Landolt-ring, it could be used as a relevant task in estimating driving ability, especially in the older population.

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VAŽNOST MJERENJA DINAMIČKE VIDNE OŠTRINE

SAŽETAK

U svakodnevnom životu ljudi su u interakciji s različitim predmetima, kako statičkim tako i u pokretu, u stvari, dinamička vidna oštrina rijetko se ispituje i provjerava u medicinskom okruženju, čak i prije izdavanja vozačke dozvole. Za sigurnost vožnje, dobar vid ili dobra korekcija s pomagalima za vid je imperativ. Osim dobrog vida, vozači moraju imati dobre reflekse i kratko vrijeme reakcije. U ovom smo istraživanju usporedili dinamičke i statičke vidne oštrine i vidjeli kako se razlikuju kod svakog pojedinca. U studiju je bilo uključeno 20 žena i 20 muškaraca u dobi od 65 godina te je napravljena usporedba s rezultatima 20 ispitanika koji su u dobi od 20 godina starosti. Dinamička vidna oštrina ispitana je uz pomoć optotipa Landolt prsten koji se simulacijom kretao brzinom od 72 km/h. T-test je pokazao da postoji statistički značajna razlika između dinamičkog i statičkog visusa kod ispitanika u dobi od 62 do 68 godina starosti ($t=15{,}852$; $df=39$; $p<0{,}01$). Kod iste grupe dinamički visus(Arit. sredina = 0,887; Stand. devijacija = 0,297) pokazao se značajno lošijim od statičkog visusa (Arit. sredina = 1,40; Stand. devijacija = 0,317). Usporedbom podataka izmjerenih kod starije grupe ispitanika i grupom mlađih ispitanika pokazalo se da postoji statistički značajna razlika ($t=2{,}275$; $df=58$; $p<0{,}05$) između starije i mlađe grupe ispitanika u dinamičkom binokularnom visusu s korekcijom. Mlađi ispitanici imaju bolji dinamički binokularni visus s korekcijom (arit. sred. = 1,063; stand. devijacija = 0,259) nego stariji ispitanici (arit. sred. = 0,884; stand. devijacija = 0,298). Razlike u dinamičkoj i statičkoj oštrini vida i njegov pad u starijim dobnim skupinama mora se uzeti u obzir prilikom izdavanja vozačkih dozvola. Budućnost istraživanja je kod ispitivanja povezanosti između dobi i vidne oštrine tako da se rezultati mogu primijeniti u praksi.