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System for measurement of the consensual pupil light reflex

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The paper presents the measurement system for quantitative investigation into the consensual reaction of pupil to light. This reaction is called the pupil light reflex (PLR). The system enables the recording and analysis of the time characteristics of pupil radius variation during PLR. In the measurement the stimulating light is projected on the left eye in so-called Maxwellian projection but the consensual reaction (*i.e*., the change in the radius) of the right eye is recorded. As a detection element the system of two linear CCD sensors has been used. Both the linear and the frequency sensitivity is determined by the technical parameters of the sensors and the optical system and are respectively 0.05 mm and 90 Hz. Moreover, a special technical arrangement makes the results of measurement independent on the horizontal and vertical movements of head relative to the recording system. This arrangement improves significantly the stability of results. In the paper the examples of PLR time characteristics obtained with the presented measurement system are shown. The influence of the time parameters of the stimulating light on the characteristics shape has been analysed.

Keywords: pupil light reflex (PLR), pupillometry, experimental set-up for measurements of the PLR.

1. Introduction

One of the most interesting features of the human eye is the pupil reaction to light (called the pupil light reflex or in short PLR). The aim of this reaction is to control the illumination of retina. Its characteristic feature is that it is consensual – when only one eye is exposed to light the second eye also reacts in a synchronic way. The reaction of the stimulated eye is called the direct reaction while in the case of the second eye it is called the consensual reaction. The change in pupil size in response to light is a result of competition between constriction and dilation mechanisms. Pupil constriction is caused by the stimulation of the circular pupillary constriction muscle (the sphincter muscle) innervated by the parasympathetic fibres. Pupil dilation is caused by activation of radial pupillary dilator muscle (the dilator muscle) innervated by the sympathetic

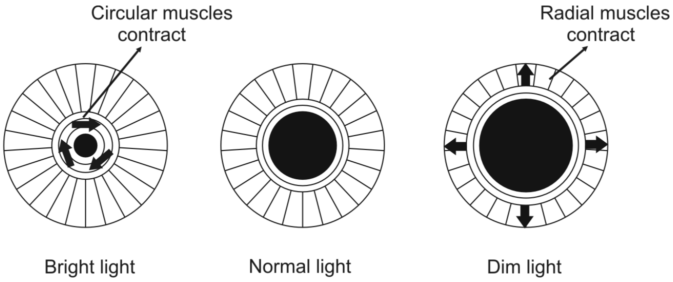

Fig. 1. Schematic view on the iris muscles action during the PLR.

fibres [1]. The scheme of those mechanisms is presented in Fig. 1 (reproduced from Ref. 1). The PLR reflex pathway includes: afferent way from the retina, central processing in the brainstem, the activity of the autonomic nervous system and local factors within the muscles of the iris (the sphincter muscle and the dilator muscle). The PLR pathway is shown in Fig. 2. Any perturbation in physiology or anatomy in the structures mentioned above may have an influence on the appearance of the PLR (direct or consensual) or on the shape of the PLR time characteristics. The analysis of the dependences is particularly interesting from the point of view of the diagnostic methods used, for example, in neurology, neuroophthalmology, physiology, psychiatry and clinical pharmacology [1]–[3].

A widely used technique of qualitative measurement of PLR is so-called „swinging flashlight test". In this technique the stimulating light is moved from eye to eye, allowing for illumination of about 3 to 5 seconds on each side. In patients with afferent

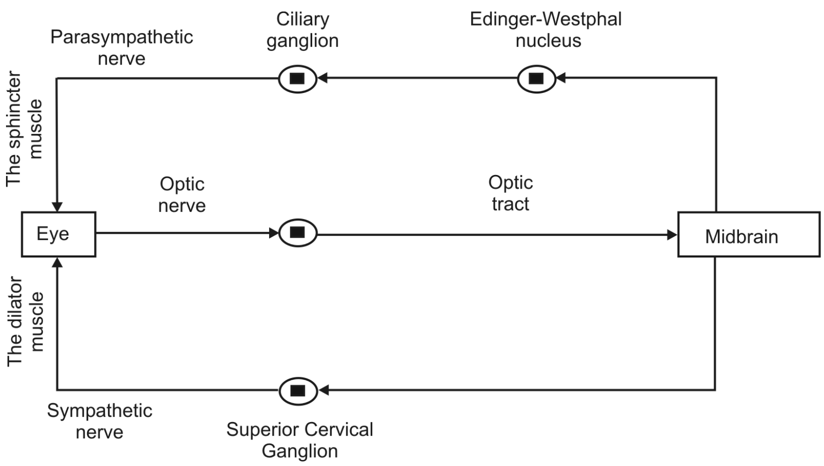

Fig. 2. Diagram presenting connections between anatomical systems being the parts afferent and efferent pathways of the PLR [1].

defects such as retinal or optic nerve lesions, both pupils dilate when the light is moved from the good (or better) to the bad (or worse) eye; and they contract again when the light is moved back to the better eye. When both eyes are equally responsive there will be a small contraction and redilation each time the light is moved in either direction. The quantitative investigation of PLR involving the recording of the time characteristics and its parameters analysis is called the „dynamic pupillometry" and the device used for such measurement is called the pupillometer. The most significant metrology parameters of the measuring system determining the measurement precision are spatial and temporary resolutions of the detectors used. The shape, amplitude, time parameteres and method of pinpointing the light stimulation on the eye are also very important. The most difficult element in the measurement of the PLR is stabilization the psychophysical conditions of the patient during measurement. A way to minimize this difficulty is to simplify the calibration process and to reduce the time of measurement. The devices constructed so far differ in the physical principles exploited, the ranges of applicability, the resolutions, the forms of results obtained and the methods of their analysis.

First pupillometers were constructed in 50 s and were using photography techniques. Disadvantages of these methods were time consuming data processing and low precision [1]. The next pupillometers were based on photoelectric measurements of light reflected from the iris of an eye [1]. It was difficult, however, to calibrate them with sufficient precision. Easier calibration and better measurement precisions were offered by next generation of pupillometers based on television systems [4]–[7]. Their disadvantages, in turn, were high costs and low time resolution of results obtained. Those disadvantages were partially reduced by systems using camera detectors [8]–[10]. Presently, though still rather expensive and having limited time resolution (maximum 60 Hz), mainly the pupillometers using CCD cameras technique are commercially available. The examples of the available devices are: Procyon P200SA (0.1 mm, 25 Hz), P_SCAN 100 system (0.05 mm, 50 Hz), CIP (0.05 mm, 25 Hz).

In this paper, the computerised measurement system to record and analyse the time -course of the PLR has been presented. The detector recording the pupil size has a form of two CCD linear sensors. It allows recording and digitizing the PLR at the rate 90 Hz. The spatial resolution of the obtained experimental results is 0.05 mm.

2. Experimental set-up for the PLR measurement

The experimental set-up for the PLR measurements is presented in Fig. 3. In the system the left eye is stimulated and the consensual response of the right eye is recorded. The system includes four basic modules: stimulation (I), recording (II), control (III) and calibration (IV). The stimulation module focuses the light in the pupil centre of the left eye. The recording module records the pupil size of the right eye. The calibration module is responsible for adjustment of the system to individual features of the subject.

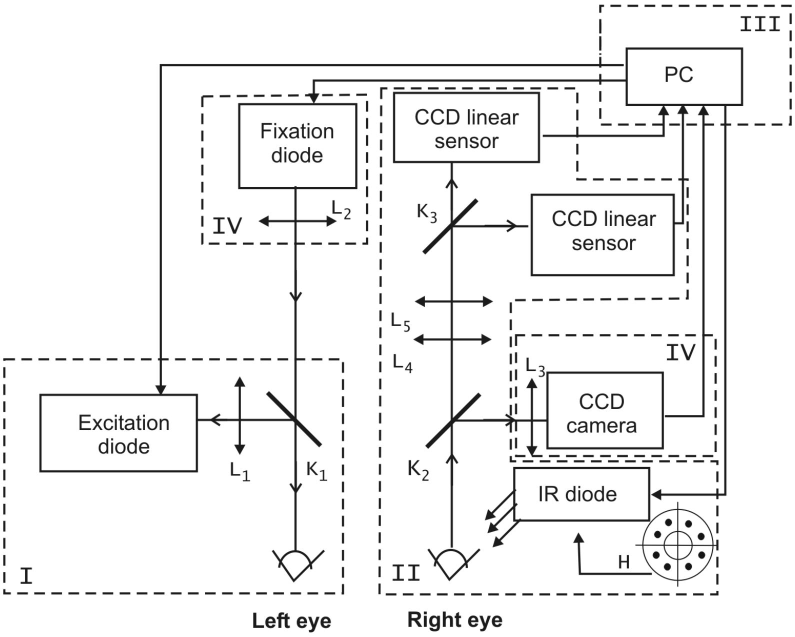

Fig. 3. Experimental set-up for measurement of the PLR (L_1, L_2, L_3, L_4, L_5 – lenses; K_1, K_2, K_3 – beam splitters; I – stimulation module, II – recording module, III – control module, IV – calibration module).

The control module enables the arrangement of stimulation parameters, registration and analysis of the experimental results.

2.1. Stimulation module

The light beam emitted by the diode (LED) is focused by the lens (f = 20 mm) into a Maxwell view on the pupil centre of the left eye. It allows keeping the constant retinal luminance regardless of the pupil size, because the spot diameter is smaller than the minimal pupil size. The Maxwellian view and the stimulation light ray path are presented in Fig. 4**a**, **b**. The system enables four types of stimulation: constant level light (I), a single, rectangular light pulse (II), a series of rectangular light pulses (III)

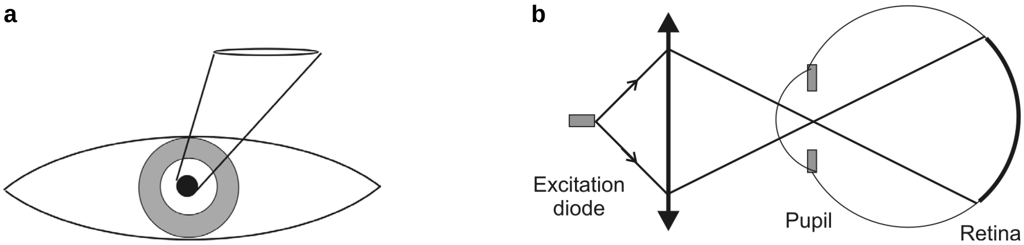

Fig. 4. Excitation module: the idea of light beam projection on the eye in so-called Maxwellian projection (**a**) and the ray diagram of stimulating light in the Maxwellian projection (**b**).

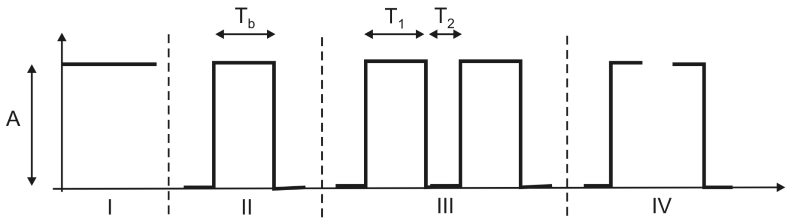

Fig. 5. Types of the stimulation light used in the experimental system; I – constant level light, II – a single, rectangular light pulse, III – a series of rectangular light pulses, IV – positive and negative steps.

and positive and negative steps (IV). The types of the stimulation light are shown in Fig. 5. The first type of stimulation provides a light for visual adaptation during the study of natural pupil oscillations (hippus) and it is used for proper adjustment of the visual stimulus. The others types of stimulation are used to induce the PLR. The parameters of the stimulation light, *i.e.*, amplitude and time duration of the light pulse, amplitude, frequency and pulse duty factor of the periodic light and amplitude of the steps are adjustable. The computer program in the control module enables selection of the particular stimulation mode.

2.2. Recording module

The aim of this module is to record the pupil size of the right eye. The module contains three parts: illuminating, optical and detecting. The first one is responsible for the illumination of the right eye with IR radiation. The IR range has been used in the system because it has no effect on the pupil size. The source of radiation is the system of eight IR diodes (λ = 940 nm) distributed along a circle placed below the right eye. The spatial configuration of this part is presented in Fig. 3 (denoted by H). A certain part of the radiation projected on the right eye reflects from the iris and the remaining part passes through the pupil aperture (being the aperture of the optical system of the eye) and falls on the retina. The rays reflected from the iris and refracted on the surface of

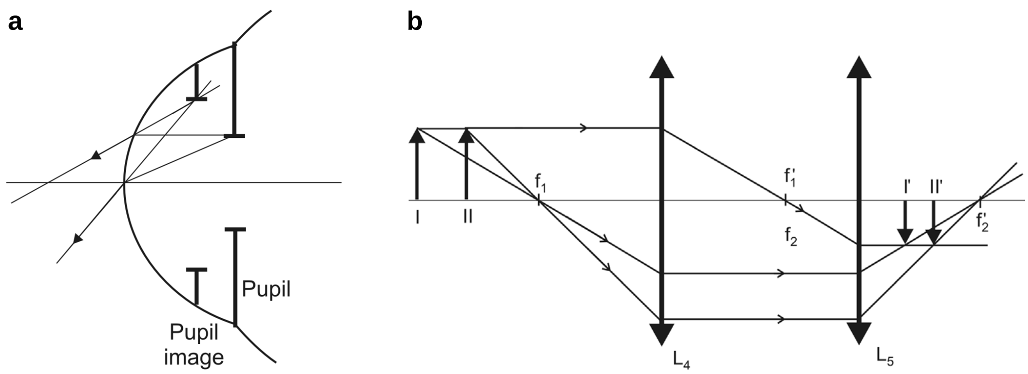

Fig. 6. Path of the light rays reflected from the iris, according to the geometrical optics (**a**), and the path of the light rays reflected into the iris through the confocal optical system (**b**).

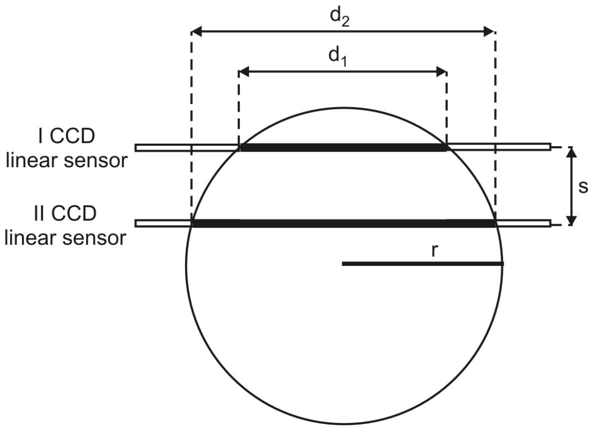

Fig. 7. Detectors system configuration.

cornea form the image of the real pupil aperture. The schematic view on the geometry of the phenomenon is shown in Fig. 6**a**. The pupil image size, because of its position with respect to the real pupil, is recorded by the measuring system and treated as the real size of the pupil. The pupil image is projected on the detection system by the confocal optical system. The light beam path in the confocal system is presented in Fig. 6**b**. The use of the confocal system makes the results of measurement independent on variation of the horizontal distance between recorded object and the detectors. The change in the distance between those elements results in the change in the position of the registered pupil image but the size of the image remains constant.

The proposed configuration of the CCD sensors allows to record two chords of the pupil (d_1 and d_2) at the distance s. Applied detector system, including two CCD linear sensors in the parallel configuration, is presented in Fig. 7. The configuration proposed makes the calculated result independent on vertical movements of head.

The applied as a detection element the system of two linear CCD sesors requires assumption that the pupil is circular. Assuming that the pupil is circular its diameter is calculated by the control module using mentioned above three parameters. The assumption is based on the analysis in [11]. In the next stage the linear and time resolution of the set-up had to be estimated. These parameters have been found by the analysis of the optical system and the technical parameters of the detection elements. At the same time these data have been corrected with the use of an artificial pupil. The optical resolution of the applied linear sensor is 24 pixels/mm. It corresponds to the resolution 0.04 mm/pixel. The result obtained for the artificial pupil is 18 pixels/mm. It is equivalent to the resolution 0.05 mm/pixel. Using the formula for the optical resolution of an objective at the diaphragm 8 the value of 185 pixels/mm (0.005 mm/pixel) has been obtained. Thus the linear resolution is determined by the resolution of CCD linear sensors and is equal to 0.05 mm.

The recording speed found experimentally is equal to 90 lines/s which correspond to the time resolution of 0.011 s.

2.3. Control module

The control module is the computer program consisting of three parts responsible for stimulation, recording and analysis. The first part allows choosing the type and the values of time and intensity parameters of the stimulation. The second part controls the collection of signals from CCD detectors and their pre-processing leading to the numerical data which are then directly analysed. The analysis consists in calculating the parameters describing the time characteristics of PLR. The direct results of the measurement are the two bitmaps in 256 grey scale, representing changes of the pupil size and stimulation signal as a function of time, Fig. 8**a**. The software designed reads the grey scale level for every pixel. The received value provides the correct classification number of that pixel. The assumed classification algorithm enables to determine the left and the right edge of the pupil (and finally pupil chord) and the light stimulation parameters. Those parameters are determined for every bitmap line.

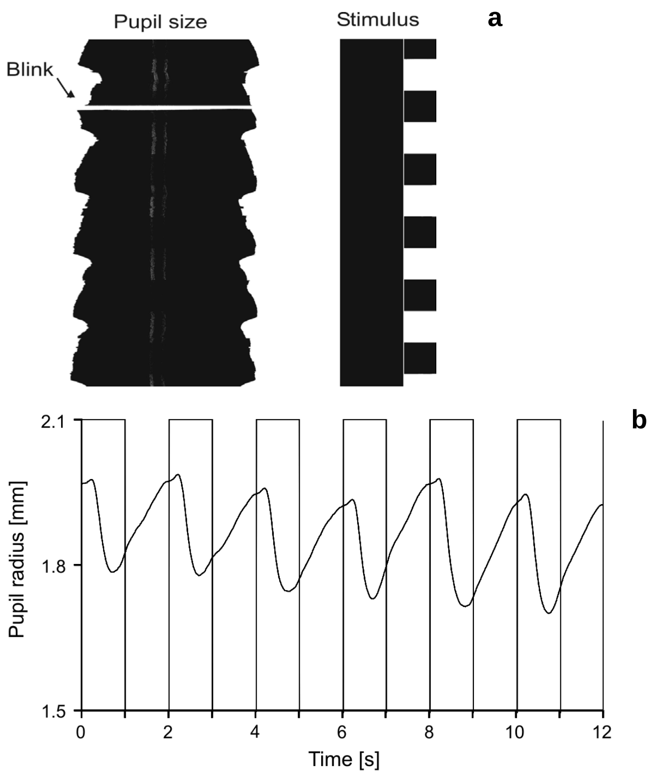

Fig. 8. PLR response: **a** – the direct result of measurement, **b** – the measurement effect result after initial analysis.

As the result of the bitmaps analysis the courses of the two chords of pupil (d_1 and d_2) and stimulation light as a function of time are obtained. Assuming that the pupil is circular the pupil radius r is determined from geometry using the following equation:

$$r = \frac{1}{2}\sqrt{s^2 + \frac{d_1^2 + d_2^2}{2} + \left(\frac{d_1^2 - d_2^2}{4s}\right)^2} \tag{1}$$

where: d_1 – the first pupil chord, d_2 – the second pupil chord, s – distance between chords. The uncertainty of so obtained radius has been assumed to be the value of the linear resolution since it is greater then the uncertainty calculated by the total differential method (of the order of 0.02). The time characteristic of the radius variation is then smoothed with the use of averaging of adjacent point's algorithm. The measurement result after initial analysis is presented in Fig. 8**b**.

2.4. Calibration module

The calibration module is responsible for adjustment of the system to individual arrangement of the subject. This module consists of CCD camera (to see if the head position is located correctly in relation to the IR diodes), a fixation point (to minimize eye movements and changes in accommodation) and a „head rest" (to optimise mechanical stability of the head with respect to the recording system). The correct pinpointing of the stimulation and the right eye position with respect to the detector system are regulated using shift mechanism.

3. Experimental procedures and examples of results

The measurement is performed after adaptation of the patient to darkness (10 minutes) and calibration of the system to the individual arrangements of the patient. During calibration and recording, the patient is asked to keep his eyes open and to look straight on the fixation point to avoid eye blink and head movements.

We can record two types of time-courses of the pupil size changes:

– Recording of the physiological changes of the pupil size as a function of time after adaptation to the steady conditions of light (natural pupil oscillations – hippus). An example of time-course of the characteristics is shown in Fig. 9.

– Recording of the pupil size changes in response to light (PLR). We can receive different time-courses of the PLR, depending on the shape of the used stimulation. The obtained PLR time-courses can be described by specific parameters.

The time-course and its derivative of the PLR induced by a single light pulse have been presented in Fig. 10**a**, **b**. The obtained time-course of the pupil size changes is described by the following parameters: time delay (T_0), time to reach minimum diameter (TA_{min}), time at which pupil has redilated to 75% of the reflex amplitude

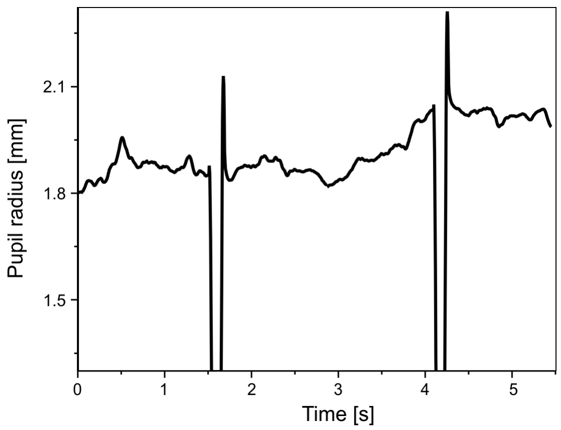

Fig. 9. Natural oscillation of the pupil size in steady conditions of light.

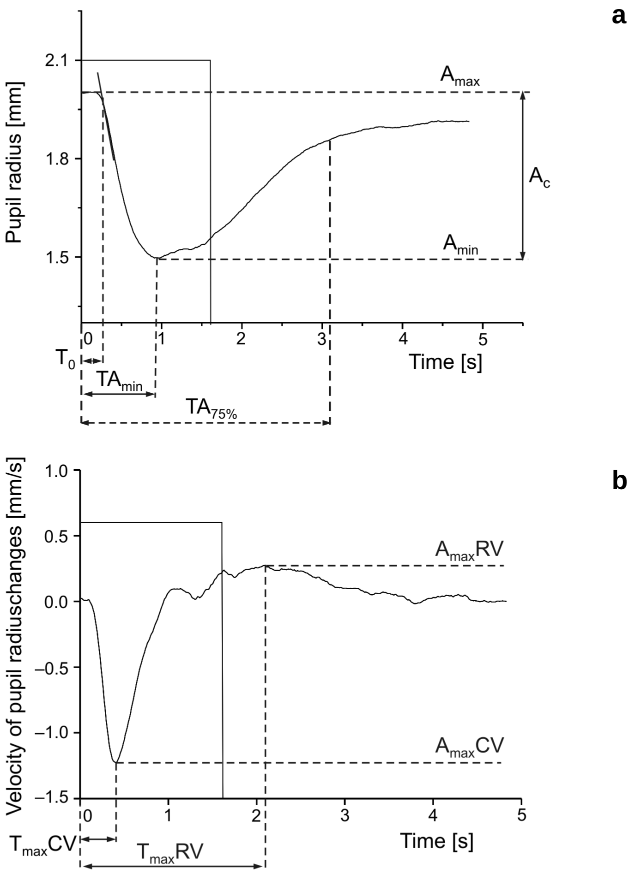

Fig. 10. PLR response to a single light pulse: time-course (**a**) and its derivative (**b**).

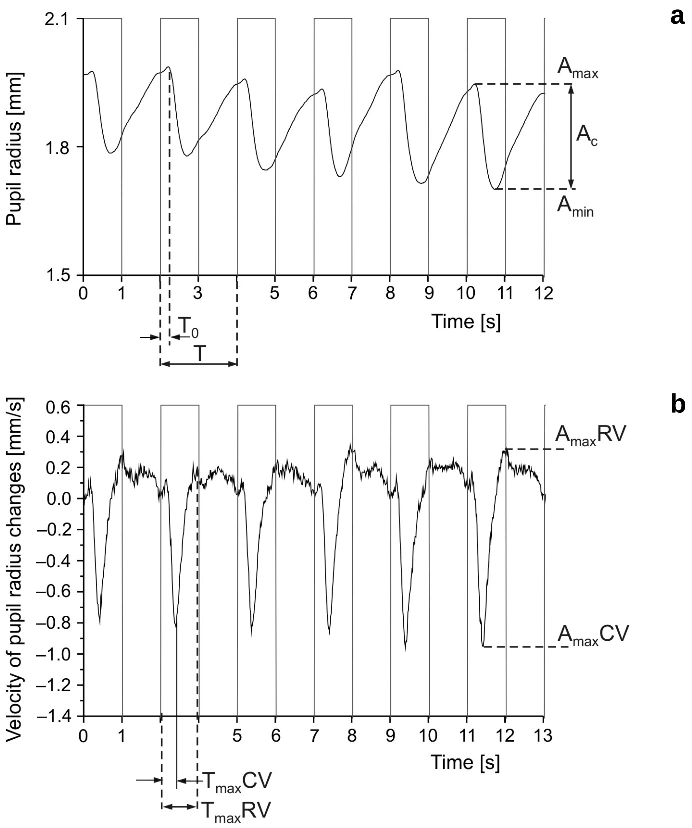

Fig. 11. PLR response to a periodic light pulses: time-course (**a**) and its derivative (**b**).

($TA_{75\%}$) and reflex amplitude (A_c). The time-course presenting the speed of pupil size changes is described by: time to maximum constriction velocity ($T_{\max}CV$), time to maximum redilation velocity ($T_{\max}RV$), maximum constriction velocity ($A_{\max}CV$) and maximum redilation velocity ($A_{\max}RV$).

The time-course and its derivative of the PLR induced by a periodic light pulses are shown in Fig. 11**a**, **b**. The first characteristic is described by the following parameters:

– coefficient of delay

$$\Psi = \frac{T_0}{T} 100\% \tag{2}$$

where: T_0 – time delay, T – period of stimulation;

– relative reflex amplitude

$$A_{cr} = \frac{A_{\max} - A_{\min}}{A_{\max}} \tag{3}$$

where: $A_{\max}$ – maximum pupil size, $A_{\min}$ – minimum pupil size.

T a b l e 1a. Parameter $TA_{\min}$ as a function of T_b.

	Person 1		Person 2		Person 3		Person 4	
T_b [s]	Mean [s]	CI [s]	Mean [s]	CI [s]	Mean [s]	CI [s]	Mean [s]	CI [s]
0.2	0.772	0.026	0.745	0.052	0.812	0.072	0.775	0.047
0.4	0.795	0.006	0.853	0.082	0.948	0.042	0.812	0.041
0.6	0.858	0.022	0.885	0.069	0.975	0.052	0.853	0.021
0.8	0.861	0.015	0.954	0.068	1.021	0.119	0.872	0.039
1.0	0.887	0.052	0.961	0.048	1.058	0.056	0.889	0.083
1.2	0.885	0.011	0.972	0.056	1.153	0.078	0.875	0.082
1.4	0.914	0.027	0.944	0.086	1.054	0.054	0.864	0.075
1.6	0.922	0.069	0.973	0.052	1.124	0.124	0.896	0.092
1.8	0.928	0.039	0.981	0.115	1.089	0.082	0.985	0.038
2.0	0.932	0.045	1.001	0.082	1.135	0.101	0.891	0.110
2.2	0.942	0.025	0.990	0.095	1.151	0.120	0.894	0.042
2.4	0.934	0.019	0.972	0.120	1.125	0.154	0.923	0.066

T a b l e 1b. Parameter $A_{\min}$ as a function of T_b.

	Person 1		Person 2		Person 3		Person 4	
T_b [s]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]
0.2	1.64	0.05	1.65	0.05	1.60	0.09	1.70	0.05
0.4	1.62	0.07	1.59	0.06	1.62	0.05	1.65	0.05
0.6	1.61	0.08	1.58	0.07	1.58	0.05	1.63	0.06
0.8	1.56	0.05	1.55	0.09	1.54	0.05	1.59	0.07
1.0	1.53	0.07	1.52	0.05	1.52	0.05	1.62	0.05
1.2	1.52	0.05	1.50	0.07	1.49	0.05	1.59	0.05
1.4	1.50	0.05	1.49	0.08	1.49	0.08	1.52	0.05
1.6	1.46	0.05	1.47	0.06	1.47	0.05	1.54	0.05
1.8	1.46	0.05	1.51	0.05	1.50	0.05	1.56	0.06
2.0	1.47	0.05	1.45	0.05	1.49	0.05	1.50	0.05
2.2	1.44	0.05	1.48	0.05	1.41	0.05	1.46	0.06
2.4	1.44	0.08	1.47	0.06	1.43	0.06	1.47	0.05

T a b l e 1c. Parameter A_c as a function of T_b.

	Person 1		Person 2		Person 3		Person 4	
T_b [s]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]	Mean [mm]	CI [mm]
0.2	0.36	0.05	0.35	0.05	0.4	0.09	0.30	0.05
0.4	0.38	0.07	0.41	0.06	0.38	0.05	0.35	0.05
0.6	0.39	0.08	0.42	0.07	0.42	0.05	0.37	0.06
0.8	0.44	0.05	0.45	0.09	0.46	0.05	0.41	0.07
1.0	0.47	0.07	0.48	0.05	0.48	0.05	0.38	0.05
1.2	0.48	0.05	0.5	0.07	0.51	0.05	0.41	0.05
1.4	0.5	0.05	0.51	0.08	0.51	0.08	0.48	0.05
1.6	0.54	0.05	0.53	0.06	0.53	0.05	0.46	0.05
1.8	0.54	0.05	0.49	0.05	0.50	0.05	0.44	0.06
2.0	0.53	0.05	0.55	0.05	0.51	0.05	0.50	0.05
2.2	0.56	0.05	0.52	0.05	0.59	0.05	0.54	0.06
2.4	0.56	0.08	0.53	0.06	0.57	0.06	0.53	0.05

T a b l e 1d. Parameter A_{cr} as a function of f (for $T_1 = T_2$).

	Person 1		Person 2		Person 3		Person 4	
f [Hz]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]
0.20	0.45	0.10	0.40	0.06	0.47	0.09	0.38	0.07
0.21	0.40	0.08	0.38	0.05	0.38	0.10	0.39	0.09
0.25	0.35	0.05	0.39	0.09	0.36	0.07	0.37	0.10
0.27	0.30	0.09	0.35	0.11	0.30	0.06	0.35	0.10
0.33	0.30	0.07	0.31	0.09	0.37	0.07	0.32	0.09
0.38	0.25	0.06	0.25	0.05	0.27	0.08	0.27	0.08
0.50	0.18	0.05	0.19	0.05	0.25	0.06	0.25	0.08
0.62	0.17	0.05	0.18	0.06	0.20	0.08	0.20	0.07
1.00	0.16	0.05	0.15	0.05	0.18	0.06	0.19	0.05
1.66	0.15	0.05	0.10	0.05	0.15	0.05	0.16	0.05

The parameters describing the velocity characteristics are the same as in the case of the PLR induced by a single pulse.

In the paper examples of results of PLR time characteristics dependence on stimulation light parameters are presented to demonstrate the capabilities of the measurement system. During experiment the time dependence of the pupil size variations for four healthy, young men (each 25 years old) were recorded. The presented dependences are the mean values from the 5 series of experiments. The time

Table 1e. Parameter Ψ as a function of f (for $T_1 = T_2$).

	Person 1		Person 2		Person 3		Person 4	
f [Hz]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]
0.20	4.688	0.150	5.000	0.211	4.231	0.150	4.300	0.215
0.21	5.171	0.583	5.285	0.177	5.120	0.583	5.062	0.185
0.25	6.440	0.292	6.272	0.727	5.617	0.292	5.800	0.251
0.27	6.657	0.667	6.830	0.651	6.854	0.325	6.450	0.268
0.33	8.165	0.758	8.290	0.793	7.769	0.421	6.890	0.368
0.38	10.020	0.432	10.590	0.524	9.000	0.300	9.560	0.420
0.50	12.209	1.055	13.085	1.215	11.396	0.950	13.103	0.652
0.62	15.743	0.854	16.273	4.911	14.062	3.150	16.829	0.851
1.00	27.866	1.568	29.645	2.844	28.108	3.895	29.816	1.120
1.66	56.850	4.350	57.125	4.872	52.015	4.235	54.145	2.325

Table 1f. Parameter A_{cr} as a function of f (for $T_1 \neq T_2$).

	Person 1		Person 2		Person 3		Person 4	
f [Hz]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]
0.25	0.48	0.10	0.51	0.12	0.47	0.12	0.46	0.15
0.28	0.46	0.09	0.42	0.09	0.40	0.10	0.40	0.12
0.33	0.38	0.11	0.32	0.11	0.36	0.08	0.39	0.10
0.40	0.30	0.07	0.28	0.08	0.33	0.06	0.35	0.08
0.50	0.35	0.06	0.24	0.07	0.28	0.05	0.25	0.06
0.60	0.25	0.05	0.23	0.06	0.20	0.05	0.20	0.07
0.90	0.15	0.05	0.10	0.05	0.14	0.06	0.18	0.05

Table 1g. Parameters Ψ as a function of f (for $T_1 \neq T_2$).

	Person 1		Person 2		Person 3		Person 4	
f [Hz]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]	Mean [–]	CI [–]
0.25	6.922	0.210	7.193	0.261	6.618	0.350	7.652	0.250
0.28	7.651	0.521	7.807	0.523	7.691	0.500	8.513	0.454
0.33	8.651	0.625	8.966	0.751	9.193	0.450	8.886	0.580
0.40	10.45	0.421	10.405	1.025	11.386	0.628	9.916	0.820
0.50	12.85	0.854	13.668	0.851	12.564	0.921	12.854	0.950
0.60	18.10	0.951	16.476	1.215	16.322	1.000	17.801	1.200
0.90	23.55	1.235	21.480	2.451	21.480	1.523	22.802	1.800

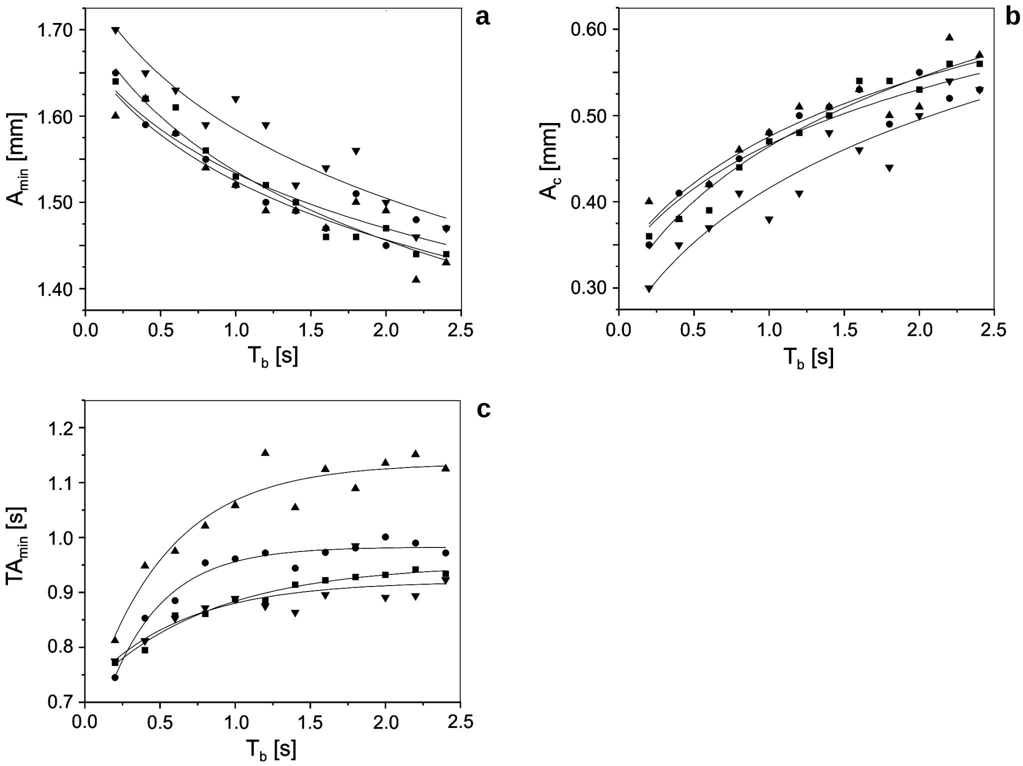

Fig. 12. Dependence of the measured PLR parameters on the time duration of the light pulse. The minimum amplitude $A_{\min}$ as a function of time duration of the light pulse T_b (**a**); the reflex amplitude A_c as a function of time duration of the light pulse T_b (**b**); the time to reach minimum diameter $TA_{\min}$ as a function of time duration of the light pulse T (**c**).

and procedure of experiment were the same in every case. To analyze the dependences two types of stimulation have been chosen, (a single pulse and a series of pulses). In the case of a single light pulse the time duration has been varied from 0.2 to 2.4 s, while in the case of the series of pulses the frequency has been varied from 0.2 to 1.6 Hz. In the first case three parameters have been analyzed: the time to reach minimum diameter $TA_{\min}$, the reflex amplitude A_c and the minimum amplitude $A_{\min}$. In the case of a series of pulses two parameters have been analysed: relative reflex amplitude A_{cr} and coefficient of delay Ψ.

In Tables 1a–g the results obtained are presented in the form of the mean value and the standard deviation. On the respective graphs the mean values are presented, in Fig. 12 for the single pulse and in Fig. 13 for the periodic stimulation.

4. Conclusions

The technical arrangements proposed in the presented measurement system lead to the improvement in precision and stability of the measurement results in comparison with

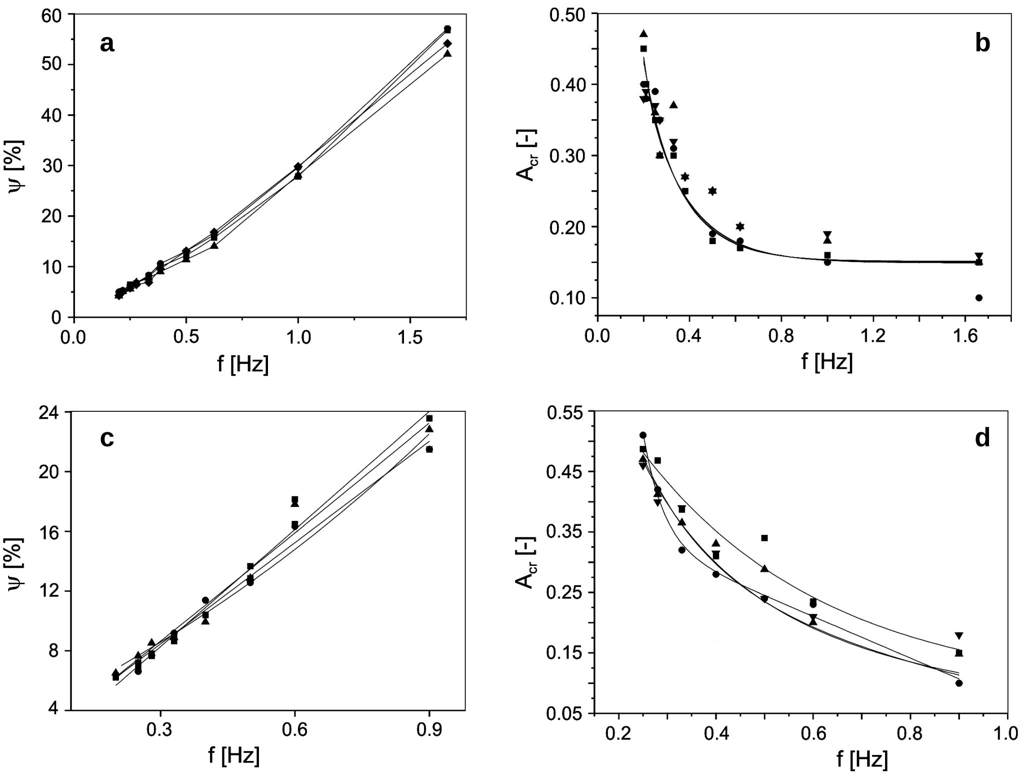

Fig. 13. Dependence of the measured PLR parameters on frequency of the light pulses series for different pulse duty factor (frequency of stimulation is defined as $f = 1/(T_1 + T_2)$; T_1 – time duration of the pulse, T_2 – time interval between pulses); **a** – the coefficient of delay Ψ as a function of frequency of the light pulses series f (for $T_1 = T_2$); **b** – the relative reflex amplitude A_{cr} as a function of frequency of the light pulses series f (for $T_1 = T_2$); **c** – the coefficient of delay Ψ as a function of frequency of the light pulses series f (for $T_1 \neq T_2$); **d** – the relative reflex amplitude A_{cr} as a function of frequency of the light pulses series f (for $T_1 \neq T_2$).

other systems commercially available. The parameters of the detectors applied result in better linear and time resolutions which has a direct influence on the precision of measurement. The detectors arrangement proposed in the form of the two parallel CCD linear sensors and the use of the confocal system make the measurement unsensitive on vertical and horizontal movements of head, which results in the improvement in the stability of measurement.

The analysis of the measured PLR time-courses exhibits the following features:

– the dependence of the minimum amplitude $A_{\min}$ on duration time of the light pulse T_b has the decreasing logarithmic character;

– the dependence of the reflex amplitude A_c on duration time of the light pulse T_b increases according to logarithmic function;

– the dependence of the time to minimum diameter $TA_{\min}$ on duration time of the light pulse T_b has the exponential character;

– the shape of the dependences obtained for the pulse light series has similar character, both for $T_1 = T_2$ and $T_1 \neq T_2$;

– the dependence of the coefficient of delay Ψ on frequency of light pulses series f increases linearly;

– the dependence of the reflex amplitude A_{cr} on the frequency of light pulses series f decreases according to exponential function.

The results obtained show the capability of the system to carry out the measurement of PLR phenomena in normal conditions for different types of stimulation. In pathological conditions it can be used as the easy and fast quantitative method for diagnostic estimation of the anatomical systems connected with the PLR pathway function. The idea of the proposed system reduces its application to measure of the pathological conditions only when the consensual reaction is maintained.

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