AN EXAMINATION OF THE PRACTICAL AND CLINICAL APPLICATIONS OF THE PUPIL CYCLE INDUCTION TEST

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Introduction

A small beam of light focused at the edge of the pupil margin can induce a rhythmic oscillation of the pupil. The oscillations can be observed and their frequency measured with a hand-held stopwatch. The time for one complete oscillation is referred to as the pupil cycle induction time and the method used to acquire this finding is known as the Pupil Cycle Induction (PCI) test. When the sharply focused thin beam of light is positioned just inside the iris margin central to the pupil, light will reach the retina and cause pupillary constriction. This constriction causes the iris margin to move toward the pupil center so that the beam of light falls outside the iris margins and the iris blocks the light from reaching the retina. The pupil will then dilate, allowing the light to once again reach the retina and the cycle will start all over. In the normal eye, this rhythmic oscillation will continue as long as the light is left in this position (Stern, 1944). The time required for each oscillation is a property of the pupil reflex arc as was pointed out by Stark, 1960.

Results from other studies done on the PCI test show some variation in mean cycle time (Table 1). Campbell and Whiteside (1950) found that the pupil cycle time was significantly correlated with different levels of illumination for the stimulus beam. This may be one reason for the variability evident in past studies. Other sources of deviation such as different slit lamps or room illuminations might also contribute to the differences found.

The PCI test can be used to detect afferent pupillary defects. The objective of this study was to determine if the P.C.I. test had practical applications which could be implemented into a typical clinical setting. The real value of the test can be understood when considering the monocular patient with an afferent pupillary defect or a patient with a bilateral defect. In both cases, the routine clinical tests for afferent defects, the objective and subjective Marcus Gunn, are of little use.

Methods

The study group contained 48 patients between the ages of 18 and 50 years. Incomplete data were obtained on six of these subjects because of either poor fixation skills or prolonged blinking tendencies. These pieces of data were deleted from the final statistical analyses.

All other subjects were correctable to 20/20 in both eyes, giving a total of 84 eyes tested. None of the subjects suffered from any apparent eye disease or afferent pupillary defects, and all subjects had intra-ocular pressures between 10 - 22 mmHg as measured with Goldman tonometry. Twelve of the subjects were optometry students or staff doctors associated with Ferris State College of Optometry. The other 30 patients were inmates at either one of two state prison facilities in the state of Michigan. Patient information including age, sex, pupil size, eye color and intra-ocular pressure was collected.

Each patient was dark-adapted in a dimly lit room for five minutes prior and during administration of the P.C.I. test. The patient was seated behind the slit lamp and asked to fixate an object positioned straight ahead at a distance of approximately ten feet. A horizontal beam of light, 0.5 mm wide, of moderate illumination was positioned at the inferior limbal margin. The light was directed straight at the patient at a 90 degree angle to the facial plane. The slit lamp viewing apparatus was positioned 15 degrees off to one side to avoid blocking the patient's fixation target from their field of view. Then the subject was instructed to hold his eye steady and refrain from blinking until instructed otherwise. Quick reflex blinks lasting less than 1-2 Hz did not interfere with measurements unless they were accompanied by slower fractional movements.

The beam was slowly elevated until it just passed the pupil margin, causing constriction. The beam was held so that during constriction the iris completely blocked the light from reaching the retina. Subsequently, the pupil would dilate until the light passed through the pupil and the cycle repeated itself. In some cases, as the basic pupil size varied with pupil unrest, it was necessary to make slight changes in the beam elevation. These adjustments were made during the first five cycles, then the beam was not moved.

The time it took for forty cycles was measured for each eye with a hand-held stopwatch. An American Optical slit lamp was used and the illumination was set at the lowest neutral density filter.

The P.C.I. test was performed on each eye twice so that replicates could be compared for repeatability. Replicates could not be obtained on one of the 42 subjects.

Means were computed for each of the characteristics measured and correlations were made between mean pupil cycle time and the subjects' age, pupil diameter, and intra-ocular pressure. The differences between the right and left eye measurements of the pupil cycle time were compared by a paired t-test.

Results

Means for the various characteristics measured on each patient are presented in Table 2. Pupil cycle times were measured over a wide range of times (785 to 1360 msec) but the repeatability of the measurements was quite close, and in fact insignificantly different by Students t-test (p=.423). The overall mean was 971msec which is closest to values obtained by Wybar in 1952 (Table 1.).

None of the characteristics observed correlated with pupil cycle time as is evident in Table 3. Also, there was no difference between pupil cycle times in the right eyes and left eyesof the subjects. To establish some normative data, the 95th percentile was chosen as a cut-off. Thus, only five percent of the population tested had a pupil cycle time in either eye longer than 1132 msec or a difference between the two eyes longer than 140 msec.

Discussion

Variation of stimulus intensity could be one reason for the variation in mean cycle time found among several studies (Table 1). Another factor, though not substantiated by clinical data, may be due to the patient population chosen for the studies. In this study, the population was 61 percent black males.

Difficulties encountered in administering the Pupil Cycle Induction test were with those patients that could not maintain steady fixation or refrain adequately from blinking for the required length of time. These people, although small in number, had to be deleted from the study group.

During the course of the study, I had the opportunity to observe two patients suffering from optic atrophy secondary to trauma. In both cases, the injury had occurred within two months prior to their visit to the clinic. Both had 20/100 or better visual acuity and an intact light reflex present in the damaged eye. A positive objective Marcus Gunn was not easily observable with either patient. The P.C.I. test was administered and an abnormal response was obtained in both cases. The damaged eyes responded in a very sluggish manner with intermittant periods of sustained dilation. The diagnosis of optic atrophy was not based solely on the results of the P.C.I. test. The presence of anisocoria, a positive subjective Marcus Gunn, and the difference in appearance between the optic nerve of the two eyes were easily observable, but in these particular cases, the P.C.I. test was more easily observed than the objective Marcus Gunn.

Conclusions

The Pupil Cycle Induction test itself is easy to administer, of relatively short duration, and reasonably repeatable. This test could be of great use in aiding in the diagnosis of afferent pupillary defects, especially in those cases where the patient is monocular or possesses afferent pupillary defects in both eyes. However, each practitioner must become familiar with the test in his or her own clinical setting to correctly differentiate normals from abnormals.

Table 1. Pupil cycle time studies.

	Stern (1944)	Campbell and Whiteside (1950)	Wybar (1952)	Miller and Thompson (1978)	Results in this paper
Normal Subjects	10	60	34	50	42
Mean ± S.D. (msec.)	752	870±148	980±97	822±69	970±91

Table 2. Means of all characteristics taken or measured on 41 subjects. Ranges of values are included.

	Mean $\pm$ S.D.	Range
Age (yrs.)	25.7 $\pm$ 5.4	18 - 41
Pupil Diameter (mm.)	5.08 $\pm$ .74	4 - 7
Intra-ocular Pressure (mmHg)	14.4 $\pm$ 2.5	9 - 20
Pupil Cycle Time #1* (msec.)	966 $\pm$ 100	785 - 1200
Pupil Cycle Time #2 (msec.)	976 $\pm$ 136	812 - 1360
Overall Pupil Cycle Time (msec.)	971 $\pm$ 90	785 - 1360

* The pupil cycle time was measured twice on each subject, one immediately following the other.

Table 3. Correlations of pupil cycle time with patient age, pupil diameter, and intra-ocular pressure.

Variable	Number of Subjects	Coefficient of Correlation
Age	42	+.184
Pupil Diameter	42	+.333
Intra-ocular Pressure	41	-.297

Table 4. Pupil cycle time means for right eyes and left eyes.

Right eyes (n=41)	962 ± . 86 msec.
Left eyes (n=41)	979 ± . 96 msec. *

* means are not different by paired t-test, p=.288.

References

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Appendix - Raw data is presented below for the 41 subjects included in this study.

OBS	ID	SEX	AGE	DIA	COLOR	SIDE	IOP	C1	C2	CDIFF
1	TP	M	25	5	BR	R	12.0	0.9675	0.8925	0.0750
2	TP	M	25	5	BR	L	13.0	0.9275	1.0200	-0.0925
3	KG	M	25	5	BL	R	12.0	0.9550	0.8925	0.0625
4	KG	M	25	5	BL	L	12.0	0.9250	0.8550	0.0700
5	SV	F	21	6	BL	R	16.5	1.0000	0.9925	0.0075
6	SV	F	21	6	GY	L	13.5	1.0600	1.0150	0.0450
7	NS	M	26	6	BL	R	11.5	0.9500	1.0150	-0.0650
8	NS	M	26	6	BL	L	12.0	0.8500	0.8675	-0.0175
9	NF	M	24	6	GN	R	14.5	0.9200	0.9500	-0.0300
10	NF	M	24	6	GN	L	15.5	1.0150	1.0550	-0.0400
11	MP	M	29	7	BL	R	12.5	1.1200	1.3600	-0.2400
12	MP	M	29	7	BL	L	13.5	0.9350	1.0050	-0.0700
13	LW	F	36	6	BL	R	12.5	0.9750	0.9800	-0.0050
14	LW	F	36	6	BL	L	13.0	0.8150	0.8550	-0.0400
15	CN	F	23	5	BR	R	11.0	1.0125	1.2125	-0.2000
16	CN	F	23	5	BR	L	11.5	1.0300	1.0675	-0.0375
17	DB	M	28	7	BL	R	11.0	1.1250	1.0625	0.0625
18	DB	M	28	7	BL	L	9.0	1.2000	1.1950	0.0050
19	RD	M	19	4	BL	R	12.0	0.9800	0.8125	0.1675
20	RD	M	19	4	BL	L	10.0	0.9925	1.0150	-0.0225
21	DS	M	24	5	HZ	R	16.0	0.8375	0.9400	-0.1025
22	DS	M	24	5	HZ	L	16.0	0.9875	1.0900	-0.1025
23	TJ	M	22	5	BR	R	18.0	0.8700	0.8950	-0.0250
24	TJ	M	22	4	BR	L	18.0	0.7850	0.8625	-0.0775
25	KM	M	20	5	BL	R	20.0	0.8900	0.9625	-0.0725
26	KM	M	20	5	BL	L	20.0	1.0300	0.8175	0.2125
27	JB	M	21	6	BL	R	15.0	1.0800	0.8550	0.2250
28	JB	M	21	6	BL	L	15.0	1.1975	1.1550	0.0425
29	JW	M	27	5	BR	R	17.0	1.0750	0.9950	0.0800
30	JW	M	27	5	BR	L	20.0	1.0325	1.0900	-0.0575
31	LF	M	23	6	BR	R	17.0	0.8975	1.0050	-0.1075
32	LF	M	23	6	BR	L	17.0	0.8875	0.9000	-0.0125
33	BM	M	20	5	BR	R	12.0	0.9750	1.1450	-0.1700
34	BM	M	20	5	BR	L	13.0	1.1325	0.9525	0.1800
35	RP	M	18	4	BR	R	16.0	0.8075	0.8575	-0.0500
36	RP	M	18	4	BR	L	18.0	0.8675	0.8200	0.0475
37	JK	M	18	5	BR	R	14.0	1.0025	0.9875	0.0150
38	JK	M	18	5	BR	L	16.0	1.1400	0.9200	0.2200
39	RS	M	18	5	BR	R	14.0	0.8275	1.1275	-0.3000
40	RS	M	18	5	BR	L	14.0	0.8600	0.9950	-0.1350
41	DR	M	30	4	BR	R	12.0	0.8450	0.9600	-0.1150
42	DR	M	30	4	BR	L	13.0	1.2000	0.9475	0.2525
43	HA	M	32	5	BR	R	14.0	0.9700	0.9600	0.0100
44	HA	M	32	5	BR	L	16.0	1.0550	1.2150	-0.1600
45	JT	M	23	5	BR	R	12.0	0.9900	1.0025	-0.0125
46	JT	M	23	5	BR	L	12.0	0.9300	0.9225	0.0075
47	EW	M	18	5	BR	R	12.0	0.9325	0.9475	-0.0150
48	EW	M	18	5	BR	L	14.0	1.0100	0.9725	0.0375
49	DK	M	28	5	BR	R	.	0.9325	0.9150	0.0175
50	DK	M	28	5	BR	L	.	1.1450	1.1200	0.0250
51	CO	M	21	5	BL	R	18.0	0.8525	0.8900	-0.0375
52	CO	M	21	5	BL	L	18.0	0.9325	1.0500	-0.1175
53	JN	M	23	6	BR	R	16.0	1.0500	0.9750	0.0750
54	JN	M	23	6	BR	L	16.0	0.9500	1.0250	-0.0750
55	HM	M	26	4	BR	R	14.0	0.8800	0.8825	-0.0025

OBS	ID	SEX	AGE	DIA	COLOR	SIDE	IOP	C1	C2	CDIFF
56	HM	M	26	4	BR	L	12	0.8900	0.8475	0.0425
57	BE	M	24	5	BR	R	17	0.8350	0.9400	-0.1050
58	BE	M	24	4	BR	L	17	1.0300	1.0075	0.0225
59	DQ	M	29	5	BR	R	16	0.8550	0.9300	-0.0750
60	DQ	M	29	5	BR	L	16	0.8975	0.8850	0.0125
61	WB	M	26	5	BR	R	16	0.8050	0.8550	-0.0500
62	WB	M	26	5	BR	L	17	0.9250	0.8325	0.0925
63	AC	M	27	5	BR	R	14	0.8750	0.9275	-0.0525
64	AC	M	27	5	BR	L	14	0.8975	0.8550	0.0425
65	WBB	M	41	4	BR	R	12	1.0300	1.1700	-0.1400
66	WBB	M	41	4	BR	L	12	1.0350	1.0450	-0.0100
67	PA	M	36	4	BL	R	14	0.9650	0.9675	-0.0025
68	PA	M	36	4	BL	L	14	0.9800	0.9000	0.0800
69	SL	M	25	5	BL	R	13	0.8500	0.8725	-0.0225
70	SL	M	25	5	BL	L	13	0.8425	0.9675	-0.1250
71	RJ	M	29	5	BR	R	18	0.9225	0.9150	0.0075
72	RJ	M	29	4	BR	L	14	0.8450	0.8625	-0.0175
73	PP	M	31	5	BR	R	17	0.9025	0.9200	-0.0175
74	PP	M	31	5	BR	L	17	0.9550	0.9350	0.0200
75	DW	M	30	5	BR	R	17	1.0250	0.9800	0.0450
76	DW	M	30	5	BR	L	17	0.9400	0.9600	-0.0200
77	SW	M	32	5	BR	R	12	1.0575	1.0050	0.0525
78	SW	M	32	5	BR	L	12	1.0800	1.0450	0.0350
79	WP	M	22	5	BL	R	12	0.9300	0.7575	-0.0275
80	WP	M	22	5	BL	L	14	0.9675	0.9475	0.0200
81	JM	M	33	5	BL	R	12	1.1400	1.1025	0.0375
82	JM	M	33	5	BL	L	14	1.1050	1.0900	0.0150