# Optimum Time Constants For The Swinging Flashlight Test: a quantitative study

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**Abstract**

*The swinging flashlight test has been used for years in optometric practice to determine the integrity of the afferent visual pathways. This paper is an attempt to quantify the duration of the stimulus directed into the eye and the rate at which the stimulus should be alternated between the eyes.*

**Abrégé**

*Le test de "Lumière alternante" est employé depuis des années par le practicien pour assurer l'integrité des voies visuelles afférentes. Ce travail est un essai de spécifier la durée du stimulus dans l'oeil et le rythme avec lequel on doit alterner la lumière entre les deux yeux.*

### Introduction

The swinging flashlight test is used to determine the integrity of the optic nerve anterior to the lateral geniculate body. Various authors have discussed the test in the literature[1,2,3,4], however, no research has been done to determine the optimum parameters which should be used to maximize its diagnostic potential. Even in healthy patients, the natural variance in pupil size may make the assessment of the anterior visual arc difficult. The purpose of this study is to determine, for the healthy visual system, the length of time that the light should be directed at each eye and the speed at which the light should be moved between the two eyes to provide the minimum variance in pupil size.

### Literature Review

The swinging flashlight test was first reported in the literature by Levatin[1] in 1959. Prior to this time, a variation of the test was used to determine the presence of optic neuritis. This test involved directing a light at both eyes simultaneously and alternately shading each eye with the practitioner's hand while watching the illuminated eye[2]. By refining the "Marcus Gunn Test" with the use of a flashlight the sensitivity and accuracy was substantially increased[1].

The pseudo-anisocoria test was developed from the swinging flashlight test by Kestenbaum[2]. During this test the flashlight is held on one eye until the pupil stabilizes. A pupil measurement is then taken and the light is directed at the other eye where the procedure is repeated. If a difference in pupil size becomes manifest, the anterior visual arc of the eye with the larger pupil is damaged. This test has certain disadvantages in that accurate measurements may be difficult if the iris is dark, and subtle changes in pupil sizes may not be detected.

Thompson[3] was the first author to define specific parameters to use with the swinging flashlight test. He provides a comprehensive set of "suggestions and cautionary hints" which are valuable to the practitioner who wants to get the most information possible from the test. Thompson suggests that the light be directed at each eye for 3 to 5 seconds and moved across the nose as quickly as possible. He states that if the light is swung too fast (approximately once per second) a sinusoidal oscillation will be set up which can hamper the interpretation of the pupil reaction. Thompson provides no research to support his suggestion which apparently is based on personal clinical observation.

Kleinstein[4] suggests that the light should be moved alternately from one eye to the other at a rate of 2 seconds per eye. Again, this appears to be based on personal experience as no experimental data were provided to support his suggestions.

### Method and Apparatus

The two parameters which were studied in this experiment were the length of time that the light should be held on each eye and the speed that the light should be moved from one eye to the other.

The apparatus was designed to provide complete control over these variables. In order to accomplish this, two 6 mm diameter fiber optic bundles were used to simulate the flashlight. These were positioned symmetrically in front of and slightly inferior to the subject's eyes. A 25 watt 120 volt incandescent bulb was mounted in a container at the other end of the fiber optic bundle and was wired into a Commodore Pet 2001

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microprocessor computer. The computer was programmed to turn on one light for 5 seconds, then turn it off and turn on the other light for 5 seconds. The interval between when one light is turned off and the other is turned on (off-time) could be varied to simulate the swing of the flashlight from one eye to the other. During each run, the off-time was constant and each light was turned on 4 times.

A Polymetric series 1163 infrared pupillometer was used to assess the diameter of the right pupil during the run. The pupillometer had input to the computer and provided it with approximately 50 pupil measurements per second. These measurements were made during both consensual and direct stimulation of the right pupil. Thus, for a given experimental run, the right pupil was stimulated directly 4 times (each time for 5 sec.), and consensually 4 times (each time for 5 sec.) The number of pupil measurements accumulated in the computer for each run was then (4 x 5 x 50) + (4 x 5 x 50) = 2000.

The computer was programmed to collect pupil values for each second of the on-time separately: in this way it was possible to examine pupil variability on a second-by-second basis. The mean, variance and standard deviation of pupil size for each second were thus determined.

Thirteen subjects were studied in this experiment. Four runs were made with each subject, using different off-times (0.00 sec., 0.04 sec., 0.14 sec. and 0.50 sec.) for each run. The first off-time (0.00 sec.) was used to simulate instantaneously moving the flashlight from one eye to the other. The largest off-time (0.50 sec.) was chosen because it simulates a relatively slow swing between the two eyes. The other times were chosen so that there was a constant interval of 0.5 log seconds separating each off-time from the next.

## Results

Table 1 shows the cumulated data of the study. The variance of the pupil diameter is used as a measure of pupil activity. Figure 1 is a plot of pupil variance as a function of the on-time of the light. The variance was largest within the first second of on-time for all four off-time intervals. From the second to the fifth second, the variance fluctuated somewhat but remained considerably lower than in the first second. It can also be seen that the runs which had an off-time of zero or 0.50 sec. have the largest variance. The runs which had an off-time of 0.14 sec. had the least variance.

To determine whether the length of the on-time had a significant effect on the pupil variance, Hartley's test was employed (see Table V and VI). In Fig. 1, using a significance level of 0.05, a significant difference was found between the variances of the 5 seconds for all four off-times. More

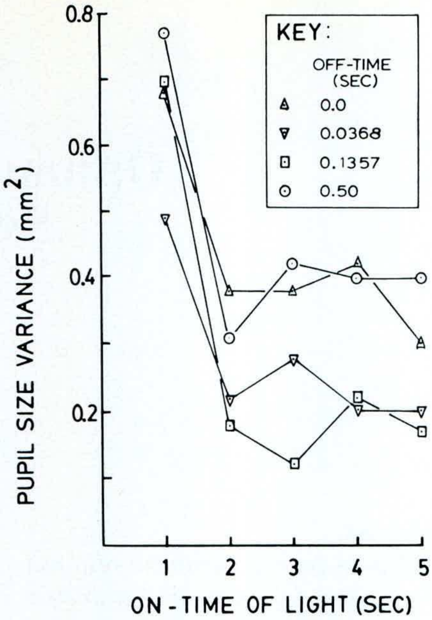


Fig. 1

**TABLE 1**

**No Interval** **N =13**

| Sec. | $\overline{X}$ (mm) | Variance (mm$^2$) | Standard Deviation (mm) |
|---|---|---|---|
| 1 | 4.748 | 0.684 | 0.827 |
| 2 | 4.734 | 0.376 | 0.613 |
| 3 | 4.954 | 0.381 | 0.617 |
| 4 | 4.982 | 0.422 | 0.650 |
| 5 | 5.109 | 0.304 | 0.551 |

**Interval = 0.0368 sec.** **N = 13**

| Sec. | $\overline{X}$ (mm) | Variance (mm$^2$) | Standard Deviation (mm) |
|---|---|---|---|
| 1 | 4.349 | 0.489 | 0.706 |
| 2 | 4.323 | 0.220 | 0.469 |
| 3 | 4.522 | 0.282 | 0.531 |
| 4 | 4.546 | 0.203 | 0.451 |
| 5 | 4.590 | 0.199 | 0.446 |

**Interval = 0.1357 sec.** **N =13**

| Sec. | $\overline{X}$ (mm) | Variance (mm$^2$) | Standard Deviation (mm) |
|---|---|---|---|
| 1 | 4.248 | 0.700 | 0.837 |
| 2 | 4.301 | 0.177 | 0.421 |
| 3 | 4.466 | 0.118 | 0.343 |
| 4 | 4.487 | 0.219 | 0.468 |
| 5 | 4.563 | 0.174 | 0.417 |

**Interval = 0.50 sec.** **N = 13**

| Sec. | $\overline{X}$ (mm) | Variance (mm$^2$) | Standard Deviation (mm) |
|---|---|---|---|
| 1 | 4.339 | 0.767 | 0.876 |
| 2 | 4.329 | 0.313 | 0.559 |
| 3 | 4.416 | 0.422 | 0.650 |
| 4 | 4.522 | 0.391 | 0.625 |
| 5 | 4.572 | 0.399 | 0.632 |

detailed analyses revealed that for all four curves, there is a significant difference between the pupil variance found in the first second and the variance found in the second second. However, no significant difference was found among the variances for the second, third, fourth or fifth second of on-time.

Figure 2 is a plot of the pupil variance against the off-time for each second of the run. The first second again shows the largest variance. The other four seconds again show lower, somewhat fluctuating pupil size variance. The variance found in the last 4 seconds decreased as the off-time increased until an off-time of 0.14 seconds was reached. The variance then increased as the off-time increased beyond this interval.

Hartley's test was again employed to determine if a significant difference existed between the variance found with the four different off-times (see Table IV). The differences were not found to be significant except in the third second of on-time. Here, the variance found when the off-time was 0.14 sec. was significantly lower than the variance found using the other off-times. The experimental data were analyzed a second time; this time treating the variances as though they were actual data points and thus reducing the degrees of freedom associated with the number of observations from infinity to 3 and 4 for the off-time and the on-time respectively (Table VII).

For this analysis the average pupil size variance for each second of on-time was found without regard to the length of the off-time interval. This was done by averaging together all of the variances that were found using a specific length of on-time. For example, the variance that was found during the first second of on-time when the off-time interval was 0.00 sec., was averaged together with the variances that were found during the first second of on-time when the 3 other off-time intervals were used. The analysis showed a significant difference in the pupil size variance between the 5 consecutive seconds of on-time.

To analyse the average variance for each off-time interval without regard to the length of the on-time, the variances found during all 5 seconds of on-time that were obtained using a specific off-time were averaged together. Using the sum of squares analysis and treating the calculated variances found in Table I as though they were raw data, a significant difference in the variances was found between the 4 off-time intervals.

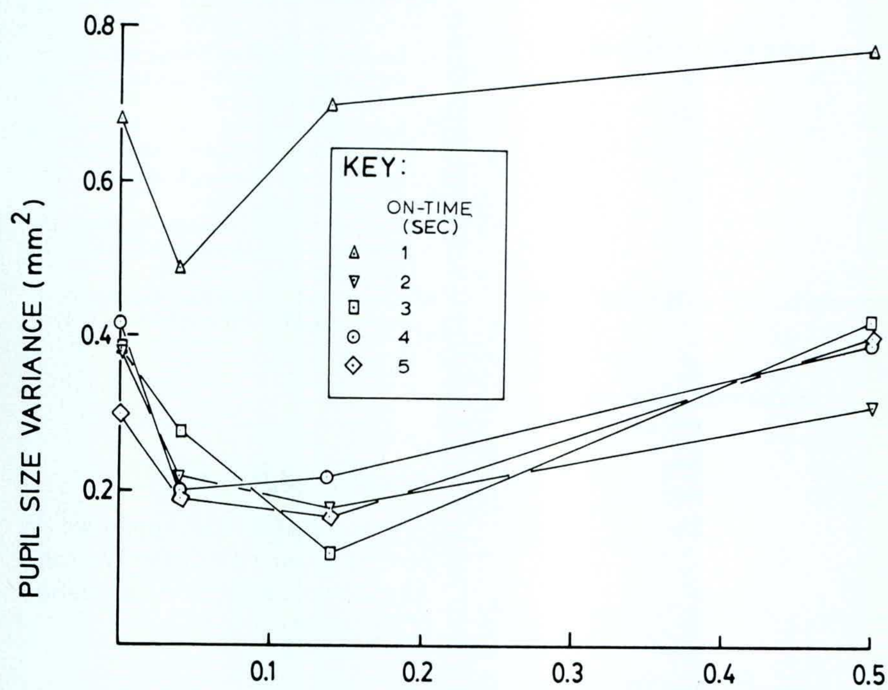


Fig. 2

## Discussion

The results of this experiment indicate that both of the parameters studied have an effect on the variance of the pupil size. Of the two, the length of time that the light is held on each eye appears to be the more important. The pupil size normally fluctuates more during the first second of direct or consensual light stimulation than it does during subsequent stimulation. This difference in pupil size variance is statistically significant. The clinical significance can be seen when it is realized that during the first second the pupil will fluctuate by more than 1.6 mm for 30% of the time it is observed. When the light was held on the eye for at least 2 seconds the fluctuation can be reduced by approximately 0.6 mm.

The experimental results also indicate that the pupil variance tends to be minimized when an off-time interval of approximately 0.14 seconds is used. This simulates a moderately fast swing between the two eyes. The highest pupil size fluctuation was found when a slow swing of 0.50 sec. was simulated. The differences in pupil size variance that are based on the differences in the simulated speed of the flashlight swing were not highly significant statistically or clinically. Maintaining a swing of 0.14 seconds reduced the standard deviation of the pupil size by only 0.2 mm when compared with a swing of 0.50 seconds. This means that when a 0.14 second off-time is used with an on-time of 2 seconds or more, 68% of the time the pupil size will not fluctuate more than ± 0.40 mm. When a 0.50 second off-time is used with an on-time of 2 seconds or more, the pupil size will fluctuate within ± 0.60 mm 68% of the time. This small difference will

**TABLE II** All off-times averaged together

| Sec. | $\bar{X}$ (mm) | Variance (mm²) | Standard Deviation (mm) |
|---|---|---|---|
| 1 | 4.421 | 0.660 | 0.811 |
| 2 | 4.422 | 0.271 | 0.515 |
| 3 | 4.589 | 0.301 | 0.535 |
| 4 | 4.634 | 0.309 | 0.548 |
| 5 | 4.708 | 0.269 | 0.511 |

**TABLE III** All on-times averaged together

| off time interval | $\bar{X}$ (mm) | Variance (mm²) | Standard Deviation (mm) | for on-time ≥ 2 sec. Standard Deviation (mm) |
|---|---|---|---|---|
| 0.00 | 4.905 | 0.433 | 0.652 | 0.608 |
| 0.04 | 4.466 | 0.279 | 0.521 | 0.474 |
| 0.14 | 4.413 | 0.278 | 0.497 | 0.412 |
| 0.50 | 4.436 | 0.458 | 0.668 | 0.616 |

**TABLE IV** Analysis of off-time-Hartley's test

| on time Sec. | Fmax | $F_{4,\infty}$ (0.05) F score needed | Significant Difference |
|---|---|---|---|
| 1 | 1.57 | 2.37 | No |
| 2 | 2.12 | 2.37 | No |
| 3 | 3.58 | 2.37 | Yes |
| 4 | 2.08 | 2.37 | No |
| 5 | 2.29 | 2.37 | No |

**TABLE V** Analysis of on-time effect — All 5 seconds — Hartley's test

| Off time Interval | Fmax | $F_{5,\infty}$ (0.05) F score needed | Significant Difference |
|---|---|---|---|
| 0.00 | 2.25 | 2.21 | Yes |
| 0.04 | 2.46 | 2.21 | Yes |
| 0.14 | 5.93 | 2.21 | Yes |
| 0.50 | 2.45 | 2.21 | Yes |

**TABLE VI** Analysis of on-time effect-seconds 2,3,4,5 — Hartley's test

| Off time Interval | Fmax | $F_{4,\infty}$ (0.05) F score needed | Significant Difference |
|---|---|---|---|
| 0.00 | 1.39 | 2.37 | No |
| 0.04 | 1.42 | 2.37 | No |
| 0.14 | 1.86 | 2.37 | No |
| 0.50 | 1.35 | 2.37 | No |

**TABLE VII** Sum of squares analysis

| | Degrees of Freedom | Sum of Squares | F score needed | Significance Level | Significant Difference |
|---|---|---|---|---|---|
| On-time | 4 | 0.4489 | 26.66 | 0.0001 | Yes |
| Off-time | 3 | 0.1423 | 11.27 | 0.0008 | Yes |

not likely affect the outcome of an optic nerve assessment.

**Conclusions**

**On-Time** This study indicates that when using the swinging flashlight test, the light should be directed at each eye for at least two seconds. Longer stimulation does not significantly affect the variance in pupil size. Conversely, stimulation of less than 2 seconds is associated with considerable pupil instability in normal subjects. Stimulation of less than 2 seconds would likely reduce the value of this test in abnormal subjects as well.

**Off-Time** An off-time of 0.5 seconds is associated with considerable pupil variance during the first second of stimulation. Ideally, an off-time of 0.14 seconds would further reduce pupil variance when on-times of 2 seconds or more are considered. However, the reduction associated with an ideally timed swing is not highly significant clinically.

## References


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## Acknowledgement


This research was supported in part by a grant from the Women's Auxiliary of the Ontario Association of Optometrists.