

Stimulus Parameters for Goldmann Kinetic Perimetry in Nonorganic Visual Loss

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Key Words

Nonorganic visual loss • Functional visual loss • Visual fields • Perimetry • Diagnostic techniques

Abstract

Objective: To investigate the influence of the stimulus parameters on perimetry at various distances and draw conclusions for the clinical exploration of nonorganic visual loss. **Methods:** Visual field testing using Goldmann kinetic perimetry was performed on 15 healthy volunteers. The I/1e isopter at 33 cm was compared to the I/1e, II/1e and I/2e isopters at 66 cm. The O/1e isopter at 33 cm was compared to the O/1e, I/1e and O/2e isopters at 66 cm. **Results:** Doubling the examination distance without adjusting the stimulus parameters resulted in significant perimetric visual field constriction. Doubling the stimulus diameter resulted in perimetric visual field expansion by a factor of 2.26 and 3.32 for I/1e and O/1e, respectively. Increasing stimulus luminance by a factor of 3.17 caused expansion by a factor of 2.15 and 2.32 for I/1e and O/1e, respectively. **Conclusions:** To avoid falsely diagnosing visual field constriction, stimulus parameters need to be adjusted when visual field testing is performed at double distance. Increasing stimulus luminance was more appropriate than augmenting stimulus size.

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Introduction

Nonorganic visual loss (NVL) is not an unusual problem in a comprehensive ophthalmologist's practice. Patients most commonly report visual acuity loss and/or visual field defects [1]. On rare occasions, other ophthalmologic symptoms are mimicked such as extraocular eye muscle palsies, color vision deficits, photopsias or ocular pain. The incidence in unselected adult eye patients has been reported to be up to 5% [2–4]. The condition is most prevalent in the second and third decades of life. Females are predominantly affected [5, 6].

NVL represents a spectrum of diseases. Malingering refers to willful and deliberate feigning or exaggeration of symptoms, while hysteria describes a subconscious expression of nonorganic symptoms. Exact differentiation is often not possible. For evaluation, the classification is of little importance because patients are examined by similar techniques. However, for appropriate treatment it is important to distinguish between the two conditions. Moreover, it is essential to be aware that a significant number of patients with actual organic disease show functional overlay [5, 6]. This makes the evaluation of patients with NVL even more difficult.

The experienced physician very often suspects NVL after careful history taking. It is then crucial to rule out any organic disease before making the diagnosis. How-

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ever, extensive testing should be avoided to prevent a chronic course of the disease [7]. Compassion and reassurance are the cornerstone of treatment. If there is an absolute certainty about malingering, a confrontation can be considered.

Nonorganic visual field loss (NVFL) has been reported to be present in 90% of patients with NVL [5]. The methods of choice for NVFL testing are Goldmann kinetic perimetry or tangent screen testing, because for NVFL no specific automated perimetry programs exist [8]. Concentric constriction of the visual field is the most common NVFL pattern [9]. True concentric field loss can be caused by end-stage glaucoma or tapetoretinal degeneration. To investigate this type of visual field defect kinetic perimetry is often performed at two different distances. According to simple geometric laws, the perimetric visual field is expected to enlarge if the distance to the screen is increased. Failure to expand is considered to be nonphysiologic and indicative of a functional component. Commonly, the testing distance is doubled. Although it seems rational to increase stimulus visibility at double the distance, some examiners reuse the same stimulus. It was the purpose of this study to investigate the influence of stimulus parameter adjustments on kinetic visual field testing in healthy subjects.

Materials and Methods

Fifteen healthy volunteers (4 males and 11 females) between the age of 20 and 45 (median 25 years) were included in this study. One eye from each participant was randomly chosen for the examination. Corrected near and distance visual acuity was at least 20/20. Eight persons wore contact lenses; the other 7 did not need correction. Spectacles were not allowed in this study. All participants had a normal slitlamp and undilated fundus examination. Intraocular pressures were below 21 mm Hg.

Goldmann kinetic perimetry (background luminance 10 cd/m²) was performed under monocular conditions for 24 half-meridians with centripetal movements (1–2°/s) of the stimulus. All examinations were performed by 2 experienced perimetrists. Fixation was controlled through the telescope of the perimeter. Pupil diameters were between 3.0 and 6.0 mm (median 4.0). Firstly, the response to the I/1e stimulus was determined at 33 cm. Thereafter, the response to the 0/1e stimulus was recorded in the same way for the same distance. Then, the subject's distance to the screen was doubled. This order of examination, first usual then double distance, was not randomized, since it corresponds to the clinical workup strategy for patients with concentric NVFL. For testing at double distance, the chinrest of the Goldmann perimeter was removed. A freestanding identical headrest was used to seat the subject. The isopters for the II/1e, I/2e, 0/2e, I/1e and 0/1e stimuli were determined as previously described at a distance of 66 cm. The angular centripetal movement speed was maintained.

For all stimuli and distances the angular distance from the fixation target for all 24 meridians was manually transferred to a spreadsheet. To allow averaging for all eyes, the meridians of the left eyes were normalized according to right eyes. The I/1e isopter at 33 cm was compared to the I/1e isopter at 66 cm, the II/1e isopter at 66 cm and the I/2e isopter at 66 cm. The same procedures were applied to compare the 0/1e stimulus at 33 cm to the 0/1e at 66 cm, the I/1e at 66 cm and the 0/2e at 66 cm.

Statistical analysis was done by taking two different approaches. For each individual, the paired t test was used to assess whether the tested isopter at 66 cm was statistically different from the reference isopter at 33 cm. The p value was set at 0.05 and the Bonferroni correction for multiple testing was applied. Secondly, we calculated for each individual and each testing meridian the fraction for the perimetric angular position between the tested isopter and the I/1e isopter at 33 cm, the denominator always being the angular position for the 33-cm distance and the numerator being the position for the double distance. By doing so, interindividual differences are eliminated. This procedure was applied similarly for every isopter pair to be compared (e.g. I/1e at 66 cm versus I/1e at 33 cm, II/1e at 66 cm versus I/1e at 33 cm, I/2e at 66 cm versus I/1e at 33 cm). For each individual the mean of this fraction was then calculated. Finally, the mean of these means was determined with the corresponding 95% confidence interval (CI) for every isopter pair. We call this quotient the perimetric visual field enlargement factor (VFEF).

We certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during this research. The study was performed according to the tenets of the Declaration of Helsinki and approved by the Ethics Committee of the Canton of St. Gallen. Written informed consent was obtained from all subjects in this study after the nature and possible consequences of the study had been explained.

Results

All isopter position differences between normal and double distance were highly significant (table 1). Figures 1–3 show the average isopter position shift for each meridian and the corresponding p values.

Figure 1 represents the result for the I/1e stimulus presented at 33 and 66 cm. When the distance was doubled without stimulus change, the perimetric visual field seen from 66 cm was clearly narrower. The VFEF was 0.66 (95% CI: 0.55–0.77).

Figure 2 shows the effect of increasing the visibility of the stimulus at 66 cm, either by doubling the stimulus diameter or by increasing the luminance of the stimulus. The perimetric visual field enlarged approximately twice when the stimulus diameter was doubled. The VFEF was 2.26 (95% CI: 2.01–2.52). Augmenting stimulus luminance (by a factor 3.17) at the 66-cm testing distance had almost the same effect with the VFEF becoming 2.15 (95% CI: 1.88–2.42).

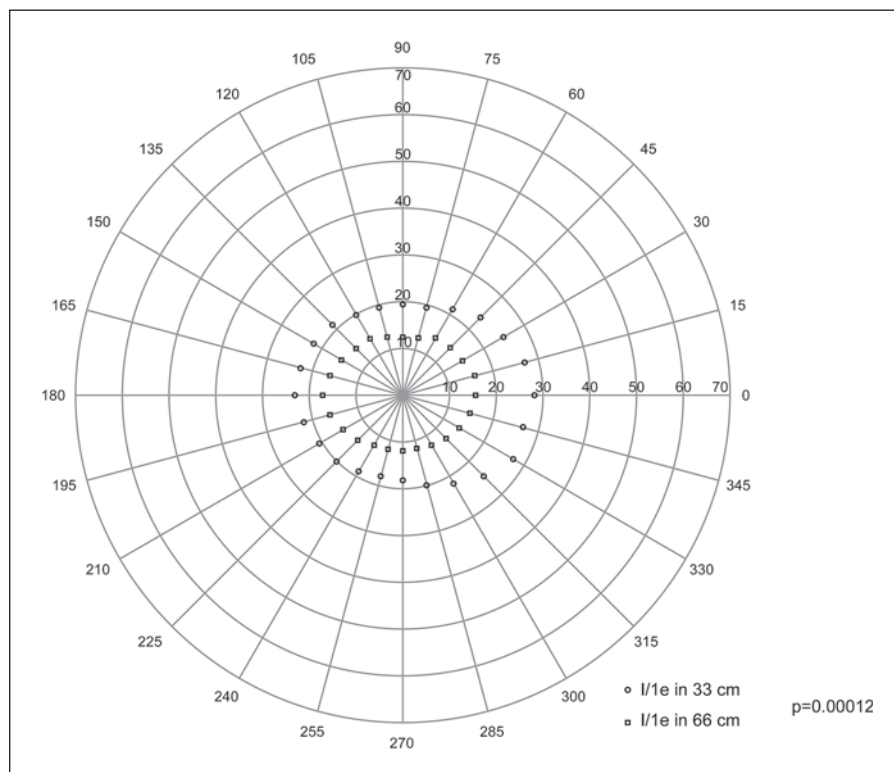


Fig. 1. Isopters for stimuli I/1e at 33 and 66 cm.

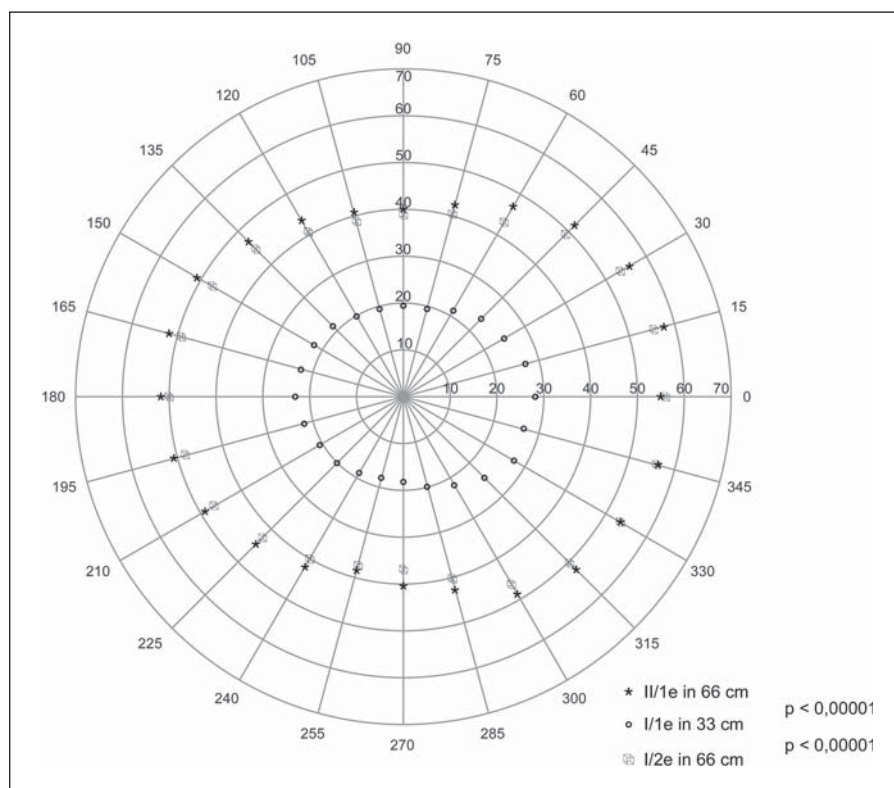


Fig. 2. Isopters for I/1e at 33 cm, II/1e at 66 cm and I/2e at 66 cm.

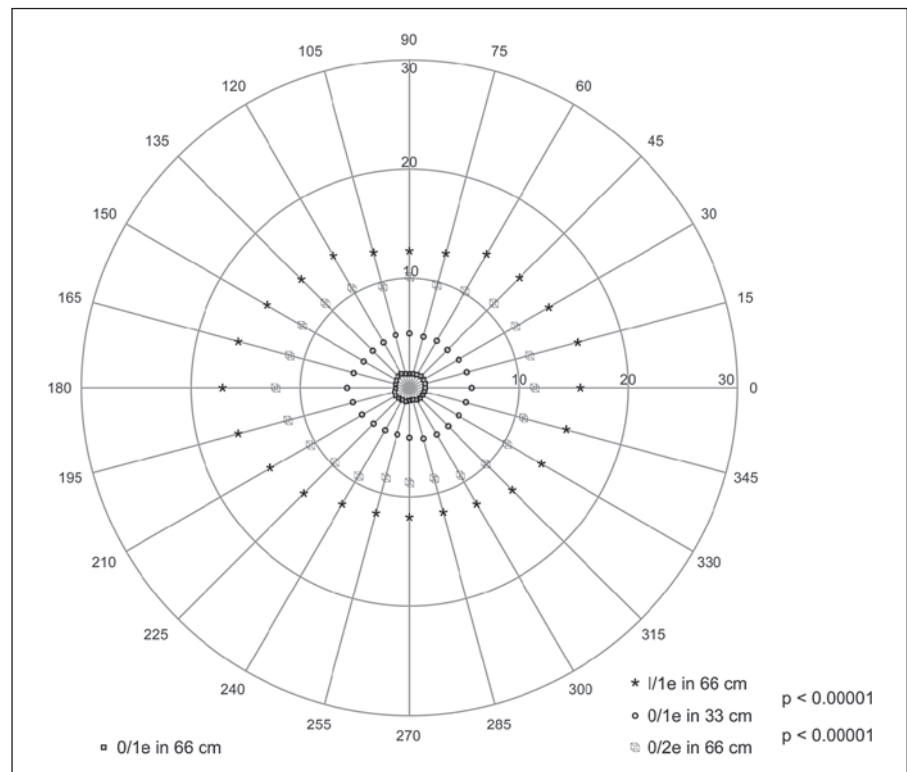


Fig. 3. Isopters for 0/1e at 33 and 66 cm, I/1e at 66 cm and 0/2e at 66 cm.

Figure 3 shows the same experiments for the 0/1e stimulus. When the stimulus 0/1e remained unchanged, doubling the presentation distance resulted in a strong perimetric visual field constriction. The VFEF was 0.32 (95% CI: 0.25–0.39). When the stimulus diameter was increased twofold at 66 cm, the perimetric visual field enlarged more than twice. The VFEF in this setting was 3.32 (95% CI: 2.69–3.96). When stimulus luminance was increased by a factor of 3.17 at 66 cm, the perimetric visual field diameter approximately doubled. The VFEF was 2.32 (95% CI: 2.00–2.64).

Discussion

While numerous tests have been developed for nonorganic visual acuity loss [10–14], only few tests exist for NVFL [4, 7]. For concentric NVFL, performing kinetic perimetry at two different distances is useful because it often helps to differentiate between organic and nonorganic origin. Although it seems intuitive to adjust the stimulus parameters to the increased testing distance, one of the authors (D.S.M.) noticed that many ophthalmologists and even some neuro-ophthalmologists use

the same stimulus after doubling the examination distance. Adjustment is not necessary provided that the testing stimulus is always suprathreshold. However, care must be taken because in pathologic conditions retinal sensitivity can be unexpectedly decreased.

To the best of our knowledge, there is only an observational case series by Pineles and Volpe [15], which addressed the issue of stimulus parameters under altered testing conditions in kinetic perimetry. In their series visual field expansion was produced using a reversed Galilean telescope. For threshold stimuli presented at two different distances during Goldmann kinetic perimetry, we found that the use of the same stimulus at double the distance will result in significant visual field constriction (for the I/1e stimulus VFEF = 0.66; for the 0/1e stimulus VFEF = 0.32). It is only through adjusting the stimulus, either by enlarging its size or augmenting luminance, that the perimetric visual field approximately doubles in diameter. For the I/1e stimulus visual field enlargement was 2.26 and 2.15, respectively. For the 0/1e stimulus VFEF turned out to be 3.32 and 2.32, respectively.

Our results can be explained by Ricco's law, which applies to our perimetric stimulus settings (table 2). It states that if the angular diameter of the perceived stimulus is

Table 1. Perimetric VFEF

	Subjects															VFEF (95% CI)	p value (paired t test)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
I/1e 66 vs. I/1e 33	0.80	0.70	0.67	0.66	1.25	0.68	0.67	0.75	0.53	0.63	0.40	0.47	0.52	0.69	0.49	0.66 (0.55–0.77)	=0.00012*
II/1e 66 vs. I/1e 33	2.28	2.10	2.45	2.12	3.71	2.10	2.06	2.04	2.64	2.18	2.11	1.84	1.87	2.03	2.44	2.26 (2.01–2.52)	<0.00001*
I/2e 66 vs. I/1e 33	2.25	2.06	2.15	2.06	3.69	2.01	1.90	2.08	2.49	2.21	1.87	1.75	1.69	1.63	2.37	2.15 (1.88–2.42)	<0.00001*
0/1e 66 vs. 0/1e 33	0.30	0.21	0.46	0.38	0.19	0.34	0.18	0.30	0.18	0.30	0.36	0.45	0.43	0.18	0.59	0.32 (0.25–0.39)	=0.00140*
I/1e 66 vs. 0/1e 33	2.34	3.08	4.67	2.75	2.23	3.63	2.90	2.39	2.11	5.12	2.17	4.67	3.94	2.53	5.32	3.32 (2.69–3.96)	<0.00001*
0/2e 66 vs. 0/1e 33	2.24	2.10	3.65	2.00	1.62	2.42	1.88	1.66	2.62	3.17	2.21	2.75	2.64	1.62	2.25	2.32 (2.00–2.64)	<0.00001*

* Statistically significant after Bonferroni correction.

Table 2. Retinal stimulus size according to distance from screen in Goldmann kinetic perimetry

Perimeter setting	0	I	II
Angular diameter at 33 cm	3.3'	6.6'	13.2'
Angular diameter at 66 cm	1.65'	3.3'	6.6'

smaller than 10' and the presenting time exceeds 100 ms, for every threshold stimulus for a distinctive retinal site the product $A \times L$ remains constant, where A is the area of the stimulus on the retina and L the luminance of the stimulus [16]. When an identical stimulus is presented at double distance, the stimulus area on the retina diminishes fourfold. To compensate for this, stimulus size can either be doubled in diameter or luminance can be increased fourfold to keep $A \times L$ on the retina constant. At double distance, the recorded perimetric visual field is expected to expand when the stimulus is seen at the same eccentricity from the fovea. Our study discloses that using Goldmann kinetic perimetry the VFEF is larger than 2, particularly if stimulus size is increased. This can be explained by the distorted perception of the perimetric bowl when the observation distance is doubled from 33 to 66 cm. At a testing distance of 66 cm, the eye-to-stimulus distance is 66 cm for central stimulus presentation. But with eccentric presentation this distance diminishes. At an eccentricity of 30°, the eye-to-stimulus distance will be reduced to 57 cm. Therefore, in order to satisfy Ricco's law, a threefold increase in either stimulus luminance or area is necessary. The most accurate manipulation on the perimeter to achieve this is increasing stimulus luminance by one step, since this will augment it by a factor of 3.17. The outcome of our study, where perimetric visual field

expansion was closer to the theoretical value of 2 when stimulus luminance was increased rather than stimulus diameter, is in accordance with these considerations.

There are several limitations to our study. Subjects were normal healthy individuals. It is possible that patients with organic defects or NVFL behave differently. However, this is unlikely as the same physical laws apply to them. Another limitation is that we performed this study using Goldmann kinetic perimetry. In the United States evaluation of nonorganic concentric visual field loss is frequently performed using tangent screen testing. Although it can be assumed that our observation also applies to tangent screen testing, we cannot exclude that this might not be the case. Finally, all of our subjects who needed refractive correction were wearing contact lenses. Since it has been shown that the visual field isopter position can be influenced by refractive errors, even outside the central 30° of the visual field [17–19], the VFEF might differ in patients using corrective glasses.

In summary, this study shows that it is crucial to adjust stimulus parameters when altering testing distance for threshold stimuli in Goldmann kinetic visual field testing. To avoid falsely diagnosing concentric NVFL, we also recommend adjusting stimulus parameters when using suprathreshold stimuli because retinal sensitivity can be reduced in pathologic conditions, rendering presumably suprathreshold stimuli unexpectedly subthreshold stimuli.

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