

Essentials of Glaucoma
The Visual Fields (part II)
Automated Perimetry
by
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This article is dedicated to review the subject of automated perimetry with special reference to the practical hints of interpreting the automated visual field. Therefore, it is essential to start with part I of the visual fields to proceed with part II.

Introduction










Beginning with a machine constructed along the basic lines of a Goldman or Tübinger perimeter, it has been possible to develop sophisticated software programs that direct the machine to perform the visual field test. Targets can be presented at any designated point or series of points within the hemispheric perimeter bowl. They can be of virtually any size or intensity. When a given program is chosen, the machine follows exactly the same pseudorandom sequence of test site presentations.

A key reason for this increased interest has been the standardization that automated perimetry allows.

With rare exception, computerized perimeters examine the visual fields using **static** techniques. The machine begins the bracketing sequence by projecting a light of such intensity that a normal patient should see it easily at the chosen test site. If the patient sees the light and responds by pushing the button, indicating “yes”, seen, the machine tests other areas of the visual field and then returns to the original site and projects a dimmer light. This process continues until the light is so dim that the patient cannot see it. The threshold has been crossed. As the test

continues, the machine increases the stimulus intensity level at the point in question.

The results of a **static threshold** test are generally expressed in a **decibel scale** derived from the reciprocal of the log intensity of the light projected; $I_{dB} = 0.1$ long unit. Because we are using a reciprocal system, dimmer lights – lights detected in more sensitive areas, are indicated by high numbers. Relatively insensitive areas are indicated by low numbers. Most current machines operate over a dynamic range of 3.5 to 4 log units (35 to 40 dB). Therefore the most sensitive areas of the visual field are represented by numbers in the middle to upper thirties. Increasingly deep scotomas are represented by increasingly low numbers down to zero. In applying these numbers to Traquair’s metaphor of the island hill of vision in the sea of darkness, the decibel numbers can be thought of as representing the height above sea level that the island rises to at the point in question. (Fig.1)

Symbol									
dB	51-36	35-31	30-26	25-21	20-16	15-11	10-6	5-1	0
asb	0.0008- 0.25	0.31- 0.8	1- 2.5	3.1- 8	10- 25	31- 80	100- 250	315- 800	1000

1 asb = 0.318 cd/m²

Fig. 1

The gray-scale, or halftone, display is perhaps the most familiar and the most comforting. In many ways it resembles a two-dimensional, black-and-white geologist’s survey map, as though the island hill of vision were photographed from directly above. Dark areas on the halftone display correspond to areas of depressed sensitivity; bright areas correspond to areas of greater

sensitivity. When viewed slightly out of focus, one can often imagine quite accurately where appropriate isopter contour lines, familiar from kinetic perimetry, would be placed on such a display.

The main drawback of the gray scale is its relative lack of precision in indicating the actual threshold of a given test point.

Analysis Of Computerized Static Perimetry

Computerized static perimetry provides numbers that represent the patient's responses to stimuli in various areas of the retina. These numbers can be manipulated mathematically and statistically to provide information about the **reliability** of patient responses and test results (**global indexes**). Although not identical, Goldmann visual field plots and computer-generated grey-scale visual field patterns usually are similar. (Fig.2)

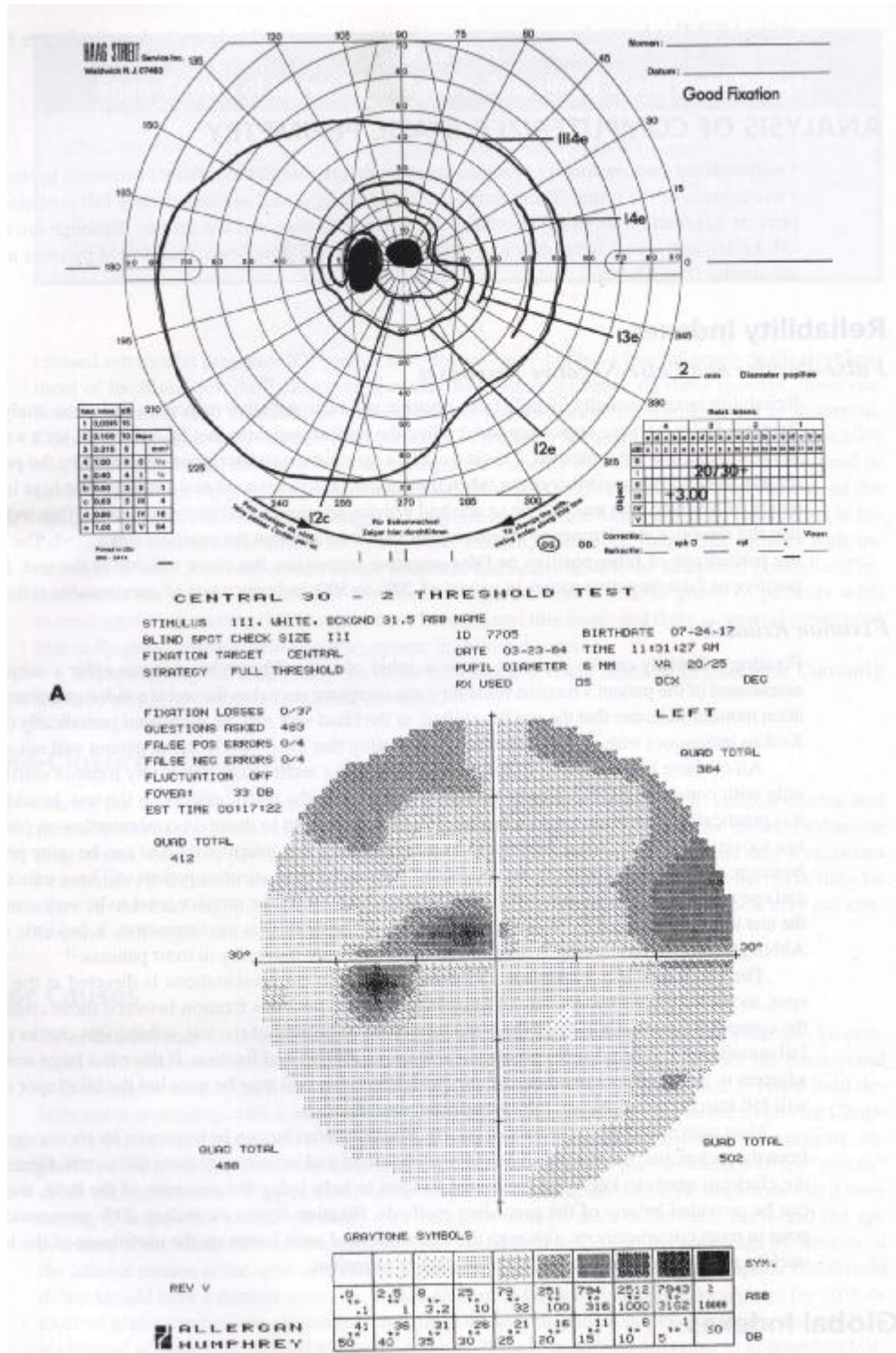


Fig. 2

A. Reliability Indexes

Reliability indexes usually include false-positive and false-negative responses and some analysis of fixation.

1. False-Positive and False-Negative Responses

False-positive responses occur when the patient indicates that he or she has seen a stimulus when one was not presented. This is usually a reaction to random noise generated by the perimeter.

False-negative responses occur when the patient fails to respond to a stimulus that is at least as bright or brighter than one that he or she had previously recognized in that position. This indicates that the response was erroneous at least one of the two times that the position was tested.

The lower the percentage of false-positive or false-negative responses, the more reliable is the test. False-positive or false-negative scores in excess of 20% to 30% indicate a test of questionable reliability.

2. Fixation Reliability

Fixation reliability can be monitored in a number of ways. The computer may stop the test if a video or infrared fixation monitor indicates that the eye has shifted; or the blind spot may be stimulated periodically (HeijlKraakau technique) with a bright stimulus, anticipating that the properly fixing patient will not see it.

Automatic fixation monitors that interrupt the test can be quite precise; however, most patients cannot fixate "perfectly". Even the most attentive patient will have minor head and eye movements associated with breathing, heartbeat, etc. If the monitor is set to be very sensitive, the test will be prolonged by frequent interruptions. If the monitor is too insensitive, it has little value. Although constant monitoring is desirable, it is probably not necessary in most patients.

The blind spot is not constant. Only one of eight to ten presentations is directed at the blind Spot, so the computer has no way of knowing about the patient's fixation between those checks. Generally, the clinician needs to know the quality of fixation to help judge the accuracy of the field, and this can be provided by any of the preceding methods. Fixation losses exceeding 20% are considered poor in most circumstances, although the exact effect of such losses on the usefulness of the test is unclear and may vary substantially from patient to patient.

Reliability factory

Finally, the “Reliability Factor” (RF) provides a mark on the patient’s cooperation. This value is calculated from the positive each trial questions. The note O is excellent; the RF value should normally not be higher than 15% for good results.

B. Global Indexes

Global indexes, which reflect the results of the visual field examination, are mathematic summaries of the actual sensitivity data produced by the examination.

1. Fluctuation

Short-Term Fluctuation

Short-term fluctuation (SF) is measured by most computerized perimeters. This statistical analysis is the result of checking several loci in the visual field twice. The Octopus G-I program tests each point in the central field twice.

The variability that is noted between each of the double tests is reported as its root mean square and defined as SF. For most

normal young subjects, overall SF is between 1.5 and 2.5 dB. SF is affected by age and eccentricity from fixation. Although the overall SF printed on the field chart may be as high as 2.5 dB in normals, a fluctuation of 2.5 dB a few degrees from fixation in a young patient with clear media is unusual, whereas fluctuation at 30° eccentricity in a normal 70-year-old individual may be 8 or 10 dB.

SF is increased in glaucoma suspects, patients who cannot cooperate well for the test, and patients who have decreased sensitivity in areas of the visual field. It is also increased in cooperative patients with significant localized field loss. In these patients the first test point may be in a fairly normal area of retina and the subsequent retest in an adjacent scotoma (or vice versa) because of a minor shift in fixation.

As a general rule a deviation should exceed about 5 dB to be considered abnormal. This rule has several important exceptions, however. Because normal variation in the parafoveal region is much less than that in the midperiphery, deviations smaller than 5 dB can represent significant reproducible pathology when they occur near fixation. Conversely, as mentioned above, a deviation of 10 dB or more may occur at 30° in a normal middle-aged patient.

Long-Term Fluctuation

Long-term fluctuation is that which occurs between two separate visual field tests.

2. Mean Sensitivity (MS)

Mean sensitivity is the average of the patient's responses for all of the points tested.

3. Mean Deviation or Defect (MD)

MD is the measurement of how the mean of the patient's responses varies from the mean of the responses of a series of normal patients of similar age under similar testing conditions. It is a statement of the generalized depression of the visual field and is useful in recognizing early diffuse visual field loss in glaucoma.

4. Standard Deviation or Variance (SD)

The standard deviation of the mean of the patient's responses is the same as the square root of the variance. The Humphrey perimeter analysis program reports standard deviation (pattern standard deviation), whereas Octopus reports variance (**loss variance LV**). Each is a measurement of the variation in responses across the visual field. Normal patients have a small standard deviation, indicating a "smooth" surface to the hill of vision. A high standard deviation or variance indicates an irregular surface to the hill of vision and may be indicative of localized visual field damage.

These indexes can be corrected by SF and then are labeled as corrected (i.e., **corrected pattern standard deviation CPSD** or **corrected loss variance CLV**). When the indexes have been corrected, they become more sensitive to recognizing true localized defects in the visual field because the variability caused by SF is removed.

MD:	-23.20 dB	P < 0.5 %
PSD:	11.08 dB	P < 0.5 %
SF:	5.90 dB	P < 0.5 %
CPSD:	8.85 dB	P < 0.5 %

Details of visual field indexes from Humphrey field analyses. MD, mean deviation; PSD, pattern standard deviation; SF, short-term fluctuation; CPSD, corrected pattern standard deviation. P values indicate the likelihood that values are normal. These values are severely disturbed.

Graphic Plots

One of the greatest values of computerized perimetry lies in the ability of the computer to analyze the numeric data and present them graphically for easier comprehension. The grey-scale printout of the Octopus was the first of these. Printouts that show variation from normal are widely available today. The Humphrey STATPAC analysis printout includes probability maps that allow quick assessment of the likelihood that a response is disturbed. Patterns of disturbed points are easily detected. These printouts can also be adjusted for generalized depression so that scotomata are more obvious. This latter function is especially useful for follow-up of patients with glaucoma and other causes of generalized depression such as constricted pupils or cataracts.

Interpretation of the results

Various computerized machines are available to test the visual field, however they follow almost same principles, therefore the results can be assessed easily.

It is very important to mention that all the computerized machines are equipped with a facility that calculates the defect due to the presence of opacities in the media (e.g. cataract).

The defect due to the media opacity is subtracted from the total defect in the field, so that the printout can show us the defect which is only due to diminished ritual sensitivity.

Two printouts for two common machines (Octopus and Humphrey) will be reviewed as examples of computerized perimetry.

Looking to (Fig.3). It represents an Octopus printout; you will find that the first line is the type of the machine and the format of the print (seven in one) is necessary for further follow up.

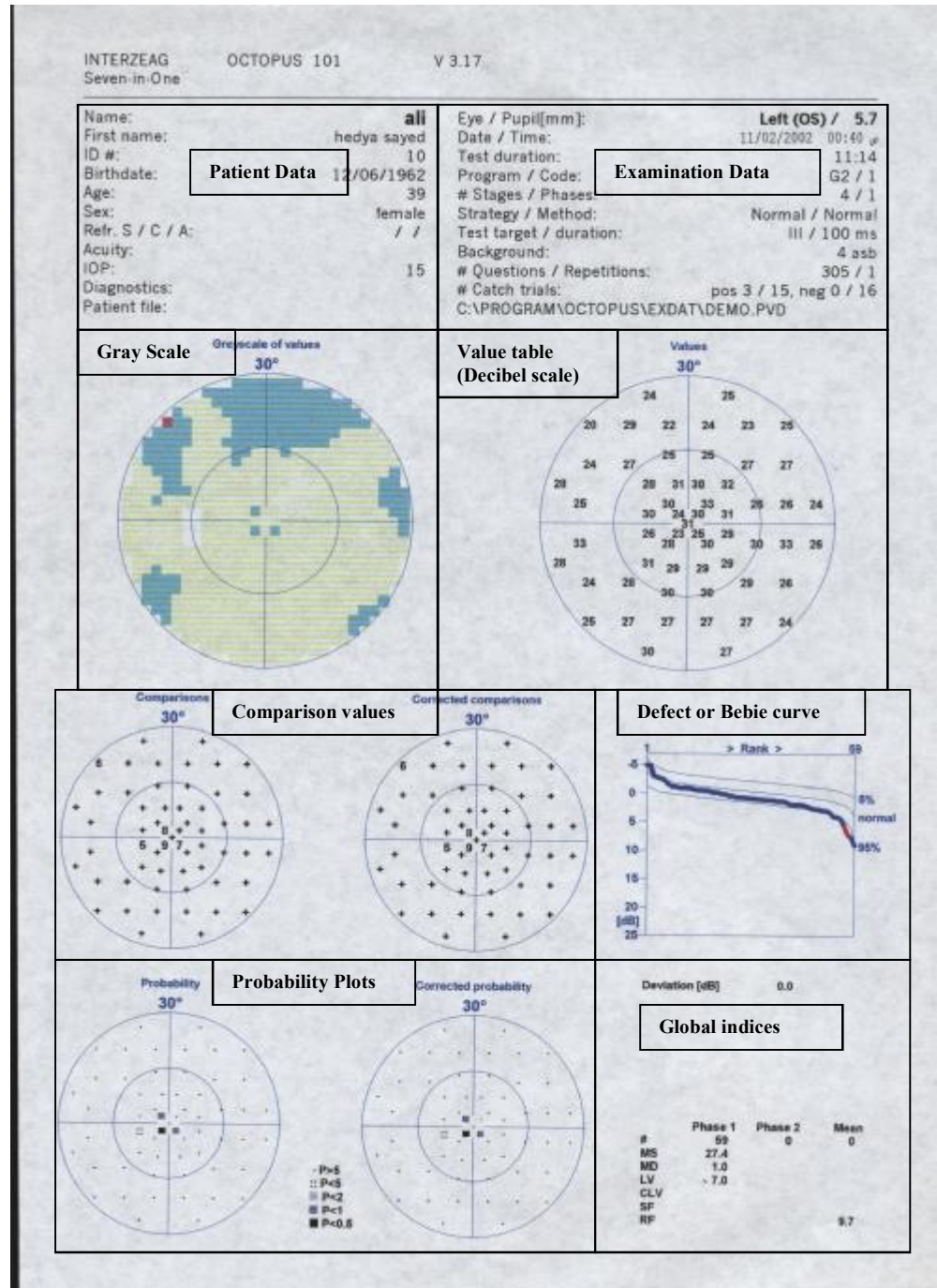


Fig. 3

Explanation of data

Patient data includes dates of birth to make calculations from the age-matched normal data base.

Examination data with info about pupil size, test duration and program parameters.

The OCTOPUS gray (color) scale depicts the sensitivities in shades. The darker the color the deeper the defect.

The value table lists the actual measured values in decibels. All other information in this report is calculated from this set of raw data. Normal sensitivities change with age. Therefore, the VA values are of little help when assessing VF damage.

The probability plots show the probability of a real defect. The full black box indicates that this location has a defect with a probability of 99.5% (100-0.5%).

Comparison values are the difference between patient test results and age-matched normals. The “+” symbols indicate normal sensitivity with a tolerance range of 4dB. In the corrected comparison table the deviation from the Bebie curve is subtracted from the defect values to show “hidden” localized defects behind any uniform loss.

Global indices provide statistical information about uniform (MD) and localized loss (LV) provide a quick and easy assessment of the field, for example the field is abnormal when $M/d = 2.5$ dB (normal tolerance range is from -2 to $+2$ dB). The reliability factor (RF) is a % value of the positive and negative catch trials. For reliable results, the RF should be under 15%.

The Defect-or Bebie curve ranks the visual field defects from the smallest to the deepest. Uniform loss (here 1.3 dJB) is clearly visible when the curve is parallel to the band of normative data. Focal defects result in a steep fall of the curve.

Applications

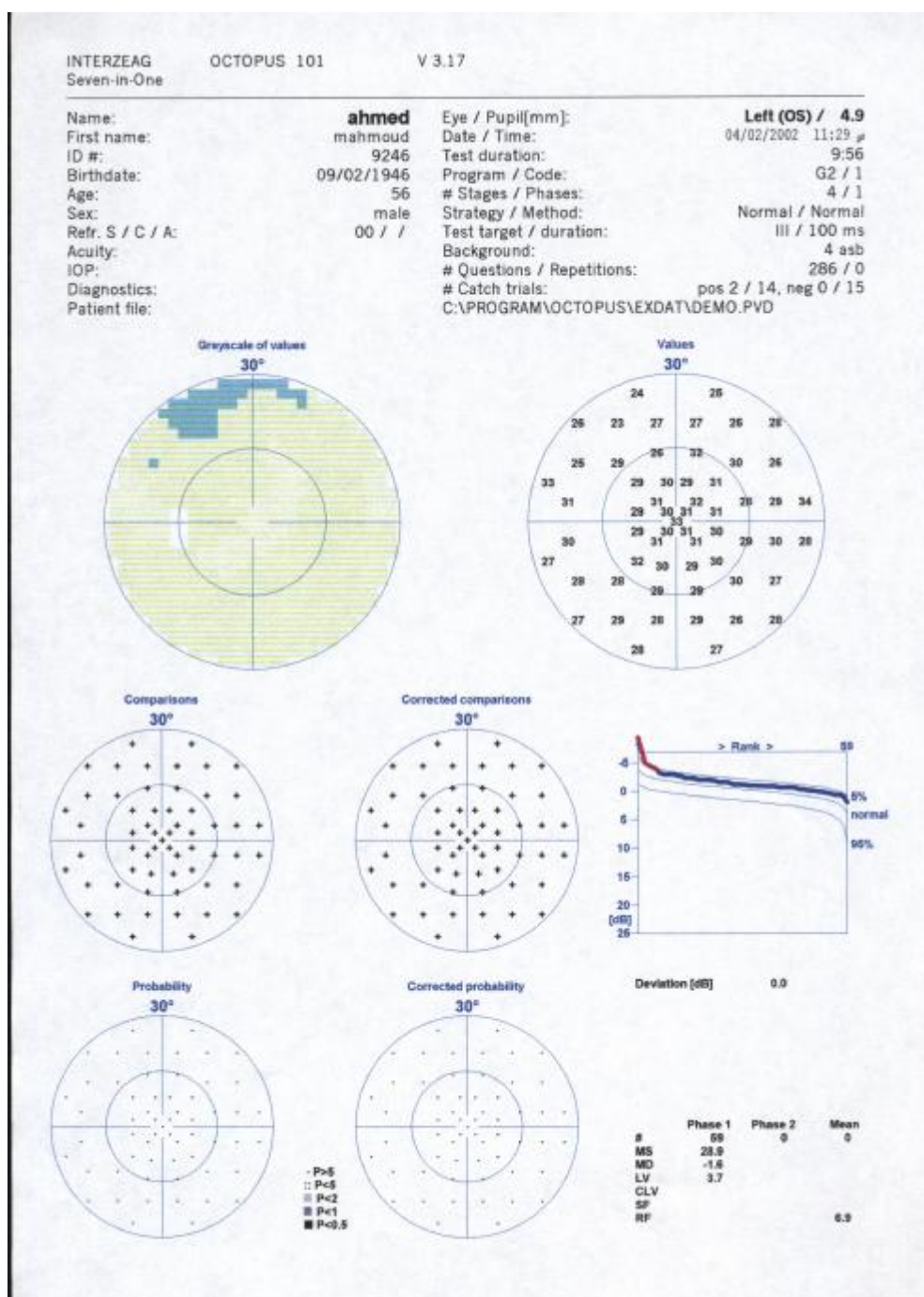


Fig. 4

Prominent Features

- **Comparison value** Compatible the age of the patient.
- **Bebie curve** within normal.
- **Probability plots** no significant change
- **Normal field**

Name:	sobhy	Eye / Pupil[mm]:	Left (OS) / 4.5
First name:	mohamed	Date / Time:	28/01/2002 11:10
ID #:	191082	Test duration:	17:48
Birthdate:	19/10/1982	Program / Code:	G2 / 1
Age:	19	# Stages / Phases:	4 / 1
Sex:	male	Strategy / Method:	Normal / Normal
Refr. S / C / A:	+5.5_ / 0 /	Test target / duration:	III / 100 ms
Acuity:	6/6	Background:	4 asb
IOP:	14	# Questions / Repetitions:	337 / 2
Diagnostics:	GLAUCOMA	# Catch trials:	pos 1 / 17, neg 5 / 17
Patient file:			C:\PROGRAM\OCTOPUS\EXDAT\DEMO.PVD

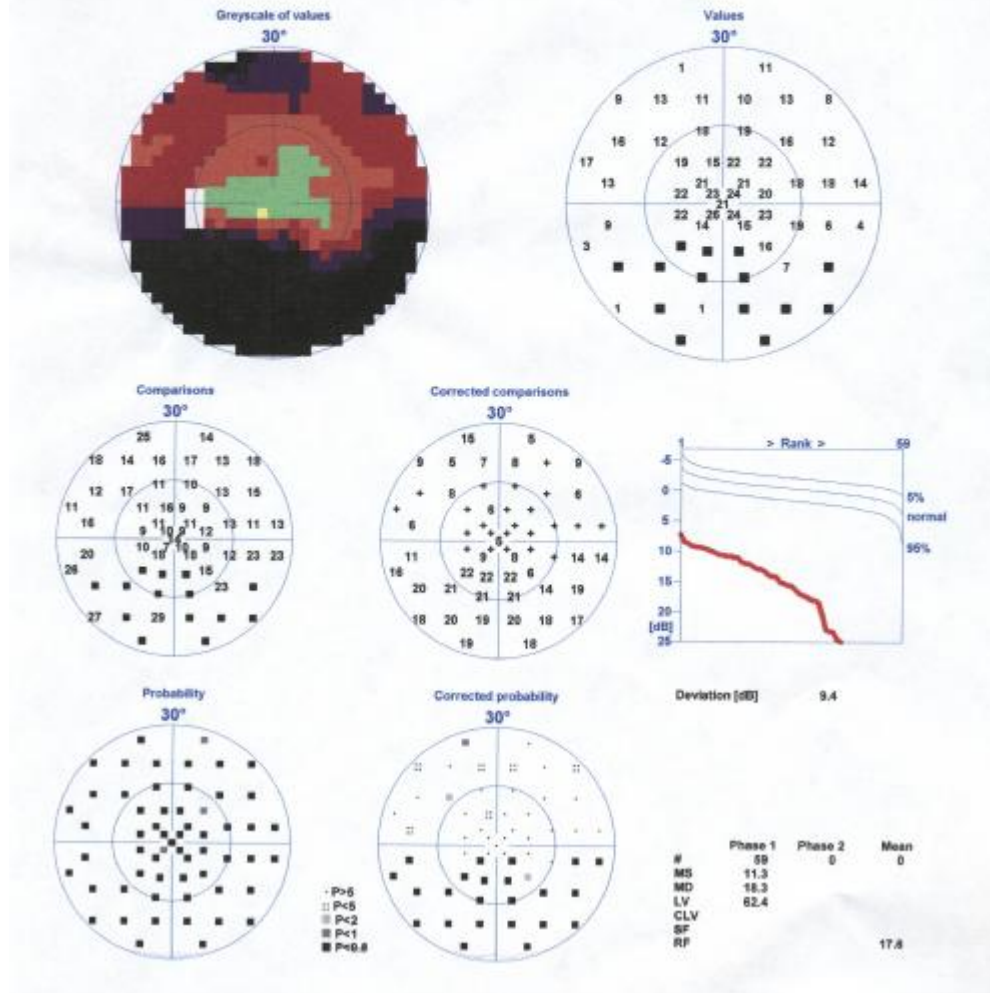


Fig. 5

- **Grey scale** Deep defect in the lower half respecting the horizontal raphe.
- **Values:** markedly deviated from age matched values.
- **Comparison values** marked defect in the lower half.
- **Probability plot** highly significant defect.

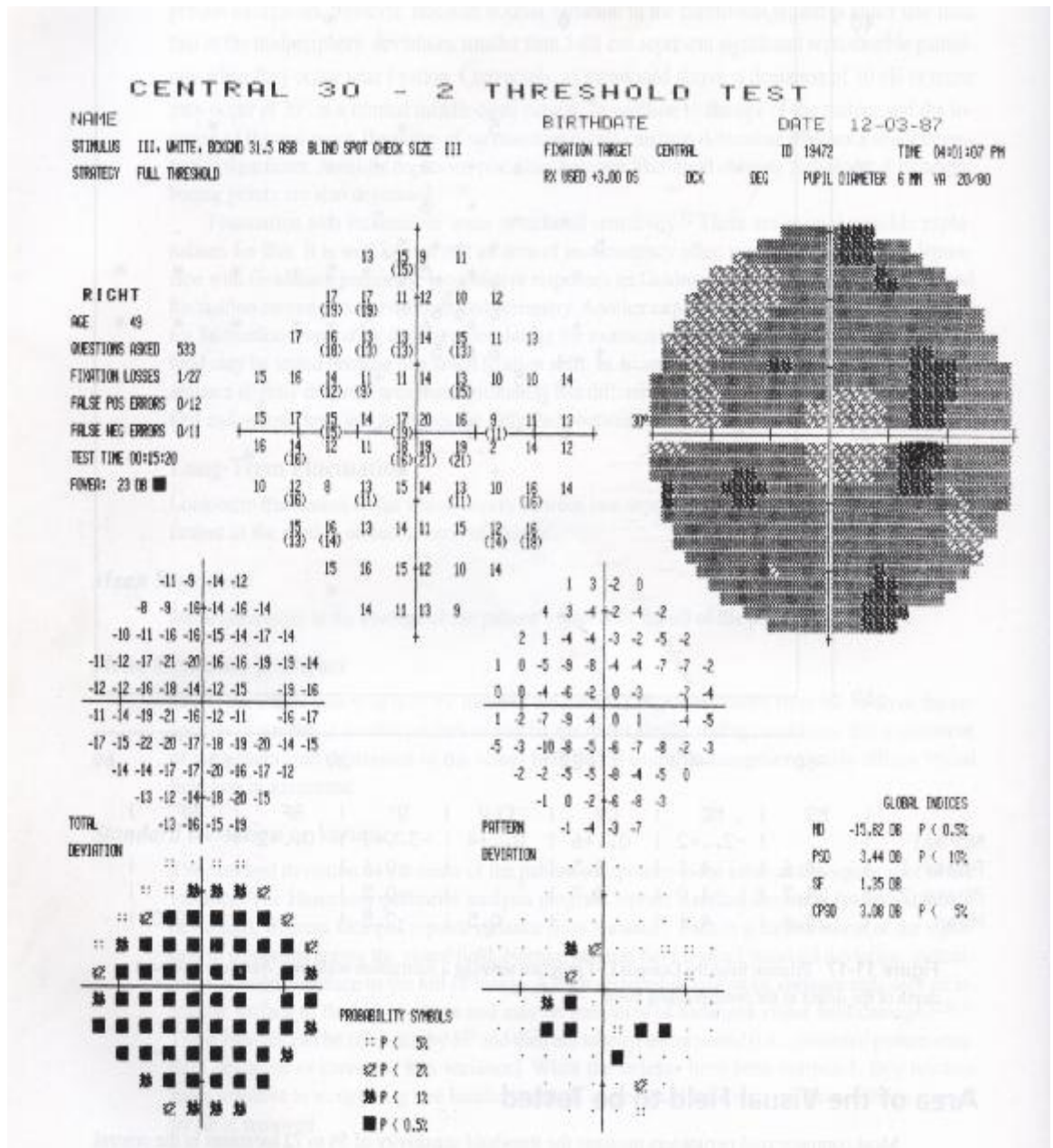


Fig. 6

Looking to fig.6., it is a printout of a **Humphrey** machine; **Patient Data** and **Examination Data** are almost presented in the same manner as presented in **Octopus** printout.

The **Gray-scale** and **Value table** follow the same principle of the Octopus.

Total Deviation is presented in two graphs to the left hand side, the upper one represents the deviation in decibels and is equivalent to the **comparison** graph in the Octopus.

While the lower one represents the significance of the defect and is equivalent to the **probability** in the Octopus.

The **pattern deviation** is also represented in two graphs, the upper right (Decibel defect) equivalent to the **corrected comparison** in Octopus.

The lower right graph represents the significance of the defect and equivalent to the **corrected probability** in Octopus.

The Global Indices

- ◆ **MD** the same as an Octopus.
- ◆ **PSD** (pattern standard deviation) is equivalent to the **LV** in Octopus.
- ◆ **CPSD** (corrected pattern standard deviation) is equivalent to **CLV** (corrected loss variance) in Octopus.

Important points to be considered:

1. The visual Field test is one diagnostic tool to be used with other clinical data to reach a diagnosis, but not the only diagnostic tool.
2. The visual field test if unreliable should be repeated during the same or another visit.
3. Comparison of the results of the same patient at intervals can be used to assess the progress of the disease.
4. Selection of the program suitable for each case is essential and requires reading the instruction manual of the machine.
5. Selection of programs of short duration might be suitable for some patients.

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- 1- David O. Harrington, Michael V Drake, The visual fields text and atlas of clinical perimetry. Sixth edition, Mosby, 1990.
- 2- Octopus Visual Field Digest, Fourth edition / Interzea (11/98) #4-0200-0070 revision2.
- 3- Robert L Stamper, Mac F Lieberman, Michael V Drake Backer-Shaffer's Diagnosis and the therapy of the glaucomas, Mosby/7999.