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Programs for diagnosis and therapy of visual field deficits in vision rehabilitation

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Abstract-A suite of computer programms is descibed for visual field-assessment of residual vision in neuropsychological rehabilitation.

1. INTRODUKTION

Recent findings of higher plasticity and limited functional recovery from visual field defects (Zihl 1979; Zihl and Cramon, 1981; Schmielau, 1989; Kasten et al., 1994, Kasten and Sabel, 1995) suggests that training patients having certain types of visual field loss is beneficial. Hence, the availability of specialised, easy-to-use techniques for restoring some aspects of visual function is important. Here we describe a suite of computer programs for the diagnosis and therapy of visual field deficits for use in neuropsychological rehabilitation. This set of programs complements commercially available perimeters. The aim is to concentrate measurements to a certain, patient-specific subfield and to provide, through automation, in that limited field more detailed information about certain low-level visual functions. Of particular interest are those functions that are typically affected, or provide differential information, in the various kinds of visual field deficits. Furthermore, a derived, slightly modified version of the programs allows the training of those same visual functions, with particular emphasis of the training in those parts of the visual field where residual function has been ascertained.

The limitations of measurement when a computer monitor is used for perimetry purposes are a natural consequence of a number of physical and optical limitations. Minimum luminance of a black monitor screen is limited by phosphor characteristics and is often visible under dark adapted viewing conditions (e.g. Di Lollo *et al*., 1996). Visual field size is limited through the monitor's physical screen size, through the min-

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imal viewing distance that must be kept in order to limit the influence of screen resolution, accomodation, and also X-ray screen radiation. A further limitation stems from the fact that the screen is not concavely spherical such that eccentric field positions are seen with accomodative error. We use a viewing distance of 30 cm such that the field size is 40° horizontally and 25° vertically. Refractive correction to that distance is advisable for subjects over 45 years of age, specifically for form recognition (*PeriForm*) at small target size but this is at the border of the programs' intended use. When only a hemifield or a quadrant is of interest, that field can be shifted by using an appropriate eccentric fixation point. Tests are done in a darkened room; the head of the subjects is stabilized with a head-support. The stimulus is presented at random positions both in the blind and intact areas of the visual field. There is no acoustic signal prior to the visual stimulus to prevent anticipatory eye movements toward the stimulus. All programs

Tab. 1: Normative data obtained from a group of 19 healthy subjects (21–-66 years age, mean 39.7) for the three diagnostic programs. Stimulus size 0.25° (PeriMat), 1° (PeriForm), 1.5° (PeriColor); black background (< 1 cd/m^2), stimulus luminance 50 cd/m^2 (PeriMat), 50 cd/m^2 (PeriForm), 25-95 cd/m^2 (PeriColor); 150 ms stimulus duration. Monocular viewing, separately for the center and the four quadrants as shown by the five squares in part of the table (table position corresponds to field position). Bold font: median, plain font: lower und upper quartile.

	Left Eye		Right Eye	
Number of correctly detected stimuli in **PeriMat** program (500 items)	**487** (465.5-489.5)	**488** (463.0-497.0)	**487** (452.0-495.0)	**488** (475.0-492.5)
	489 (481.0-492.0)		**488** (479.5-492.0)	
	487 (482.5-490.5)	**488** (465.5-495.0)	**488** (473.0-491.0)	**489** (484.5-492.0)
Number of correctly detected stimuli in **PeriForm** program (250 items)	**220** (209.0-231.0)	**221** (204.0-226.0)	**213** (192.0-219.5)	**227** (213.0-234.5)
	238 (226.0-240.5)		**229** (217.5-234.5)	
	220 (208.5-229.5)	**206** (196.0-220.0)	**194** (184.0-209.5)	**227** (217.0-232.0)
Number of correctly detected stimuli in **PeriColor** program (250 items)	**204** (170.0-213.5)	**187** (161.5-202.0)	**183** (154.5-188.0)	**209** (194.0-216.0)
	225 (206.5-235.0)		**222** (193.5-228.0)	
	203 (185.0-223.0)	**186** (166.5-193.0)	**168** (158.0-188.0)	**219** (194.0-228.5)

allow the use of different levels of stimulus and background luminance, in the range given by the monitor, and a range of stimulus sizes. The programs further allow different levels of stimulus duration (e.g. 50, 100, 150 or 200 ms) and use of randomized intervals of stimuli. Each item is presented at a given screen position only once. Correct fixation is ascertained by having a 0.5° fixation point that changes its colour, e.g. from bright green to yellow, and instructing the patient to press a key upon change. The amount of colour change can be adjusted to the patient's capabilities and there is a warning message when a subject is unable to recognize the change.

A first set of normative data was obtained from a group of 19 healthy subjects; the results are shown in Tab. 1. The measurements were done monocularly and separately for the central visual field and the four quadrants. The table shows medians (bold) and lower and upper quartiles. The program has further been extensively used for examination of patients having visual field deficits (Kasten *et al*., 1994; Kasten and Sabel, 1995).

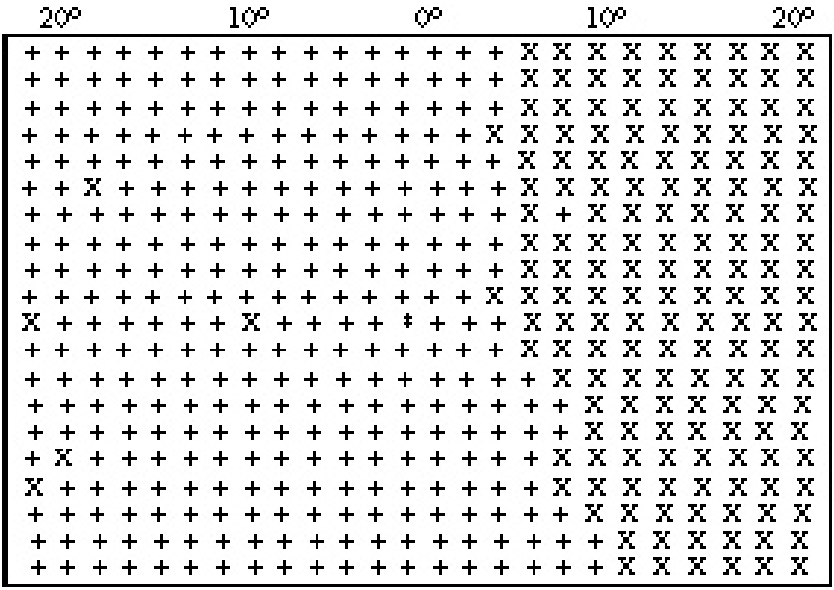

*Figure 1: Example of visual field as assessed by PeriMat. ASCII graphics are used to allow the programs to run on the whole range of MS-DOS computers. Homonymous hemianopia in a 46 years old male after an accident. (+ = detected stimulus position, X = undetected position, * = fixation point).*

2. Diagnostic programs:

PeriMat: This program examines *visual field defects*; it measures the responses to small light spots (stimulus size 0.25° – 1°, 15 – 100 cd/m²) which are presented at random positions on a monitor screen for a given duration (50, 100, 150, or 200 ms). While fixating, the patient is asked to press the space bar as soon as he or she perceives the stimulus. The stimulus is presented at 500 different positions within a period of about 20 minutes. In patients with cerebral blindness the program shows the intact and defective areas (Fig. 1).

PeriForm: The *PeriForm* program examines the patient‘s ability to *recognize simple forms* in different areas of the visual field. The stimulus set consists of letters, figures, or small lines, with four alternatives in each group (smallest size: ~1°). A session consist of 250 presentations at different positions in randomized sequence. The examination needs ~15 min.

PeriColor: This program assesses *discrimination* of broad *colour* categories in the visual field. *PeriColor* works similarly to *PeriForm*, except that coloured squares are used as stimuli.

3. Training programs:

For each task, a corresponding version of the program is available for training of that particular function. Current evidence suggests that training is most promising in areas with residual function. For each patient these areas are first determined. The patients then receive a disk with the software adapted to their respective deficit and they are instructed to train for one hour each day in a darkened room at home. The results of every session are saved onto disk for subsequent analysis. Whenever the patient has reached a pre-determined level of performance (more than 90% correct responses), the program advances to the next level where stimuli are presented further out in the blind visual field section.

Visure: The *Visure* program was developed to *train at the border* between the intact and the deficient sectors. A large white stimulus which rhythmically changes its size moves from the intact visual field into the borderline area. The patient is instructed to press a key upon detection of the stimulus. The stimulus then moves further into the direction of the blind area and continues to change its size to maximally activate residual function. If the patient is unable to see the stimulus at this position, the stimulus retracts back into the intact area and the procedure is repeated.

SeeTrain: In this program, the task is to *detect a stimulus* on a black screen. The brightness of the stimulus changes from dark gray to light white in the same position. A further training method is based on the detection of a growing black line on a gray screen. In both parts of the program task difficulty can be adjusted by changing the appropriate stimulus parameters such as size or brightness in order to adapt to the patient's specific deficit.

FormTrain: This is the training variant of *PeriForm*, for *training form discrimination.*

ColorTrain: This is the training variant of *PeriColor*, for *training discrimination of broad colour categories.*

FixTrain: this *fixation-training* program includes several procedures for patients having fixation deficits. The stimuli undergo small changes at random intervals that are not visible without proper fixation.

The tests show high objectivity, retest reliability and validity (Kasten, 1993). We have encouraging results about the effectivity of the training with these programs. In a first study the treatment group displayed a reliable enlargement of visual field size (Kasten *et al*., 1994; Kasten and Sabel, 1995). The study seems to indicate that the key to success is extended training. The programs have therefore been explicitly designed to allow home training after the areas of residual vision have been determined by the clinician. The programs use ASCII graphics in order to run on the whole range of MS-DOS computers.

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