LETTERS TO THE EDITOR

Sir,

I should like to comment on two articles on my OKP Glaucoma Visual Field Test, which were published respectively by Vernon and Quigley[1] and Wishart[2] in recent issues of *Eye*.

Vernon and Quigley compared the OKP glaucoma screening chart with the Humphrey Visual Field Analyser by testing 27 eyes of 27 glaucoma patients and 32 eyes of 32 patients with ocular hypertension. The OKP test was positive in 77% of eyes whose fields had any defective point more than −10 dB from age-matched normal values and in 92% of eyes with Corrected Pattern Standard Deviation >6 dB. The glaucomatous eyes that passed the OKP test were characterised by less severe defects on the Humphrey than those which failed. None of the ocular hypertensive eyes failed the OKP test.

Wishart also compared the OKP glaucoma screening chart with the Humphrey Visual Field Analyser in 43 patients with known field loss and 13 patients with normal fields. The sensitivity and specificity of the OKP test were estimated at 60.5% and 61.5% respectively. The number of points missed showed a near-linear correlation with the mean deviation and the corrected pattern standard deviation. However, in 13 patients visual field defects averaging 19.6 dB were not detected.

Vernon and Quigley recommend deleting numbers 18 to 26 from the central 8° of the OKP chart because all of the 17 glaucomatous eyes failing the OKP test were already detected by the first 17 numbered points on the chart. Wishart also did not find the numbers in the central 8° field useful, because field loss in this area was missed.

Vernon and Quigley recommend testing the nasal visual field at an eccentricity of 18° instead of 15° because 4 of the 10 glaucomatous eyes passing the OKP test had a peripheral nasal step. Wishart reports similar findings, with 2 of his patients having a nasal step not extending to within 15° of fixation.

Both studies are valuable in demonstrating the limitations of an OKP chart designed exclusively for the detection of advanced glaucomatous visual field loss and having only one test stimulus, which was necessarily large.

An improved 'multi-fixation campimeter' has already been developed which overcomes the problems identified in the two studies. This new hand-held chart differs from the OKP visual field test in several respects. Firstly, it has four interchangeable black stimuli, which are 1 mm, 2 mm, 3 mm and 6 mm in diameter (with a working distance of 30 cm). Secondly, the chart allows up to 60 points in the central 24° field to be examined, with additional unnumbered fixation targets at 30°. Thirdly, the normal blind-spot is surreptitiously examined two or three times during the examination by means of numbers instead of letters so that the examiner can monitor the patient's cooperation more readily. Finally, instead of providing a 'normal–abnormal' type of result, as with the original OKP glaucoma screening chart, the new chart allows different patterns of visual field loss to be recognised so as to enable differential diagnosis by trained examiners.

The availability of four stimulus sizes allows examiners to vary the sensitivity of the test according to their own capabilities and the age, visual acuity and level of cooperation of each patient. Furthermore, the stimulus size can be altered according to the eccentricity of the point being tested, thereby enabling the visual field to be examined beyond 15°, as suggested by both authors, and perhaps improving performance with paracentral fixation targets.

In his discussion, Wishart suggests that the false negative results in his study may be related to the patients looking at the stimulus during re-fixation. However, the instructions accompanying the chart clearly state that the examiner must monitor the patient's fixation at all times, sitting in front of the patient. Furthermore, the instructions also advise that the examination is more reliable if the patient is asked to state when the stimulus appears and disappears as this is covered and uncovered by the examiner, using a white card. It is difficult to understand how dense visual field defects can be missed if these simple instructions are strictly adhered to.

As stated previously, the multi-fixation campimeter is intended as a simple and inexpensive device for use only in situations where no other visual field test is possible.[3,4] The increased versatility of the new chart should increase not only its sensitivity but also its scope, so that it is helpful with neurological disorders and other conditions, not only glaucoma. However, the new chart demands greater skill on the part of the examiner, who is now required to select stimuli appropriately and to interpret the results intelligently.

Multi-fixation campimetry is still in its infancy but relies on solid research to be transformed from a mere concept to a practical clinical tool. Independent studies such as those performed by Vernon and Quigley and by Wishart are therefore most valuable.

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Sir,

We congratulate Dr. Mainster on his lucid and interesting introduction to cellular automata and the concept of chaos.[1] A number of points arise from his paper that require clarification. The fractal nature of the retinal blood vessels is now well established with values of 1.63–1.88 being reported.[2–6] Some workers have shown a difference between arterial and venous patterns[2–4] whereas others have not.[5,6] Although most studies support the concept of diffusion-limited aggregation as an underlying principle in angiogenesis, one report[7] favours an alternative hypothesis related to an invasion percolation model.

The question arises regarding the meaning of the fractal dimension of a capillary bed, stated by the author to be 1.82. A fractal is a pattern or structure that is statistically similar over a range of scales – a property known as self-similarity or scale invariance. The range of scales may be infinite in mathematically derived fractals or finite if naturally occurring in the real world. The extent to which these self-similar structures fill space is quantified in terms of the fractal dimension (D). A number of methods have been used to determine D for a wide range of different patterns including retinal vasculature (*loc. cit.*) and herpes simplex epithelial keratopathy.[8] All methods rely on the measurement of the pattern with progressively increasing measurement intervals and the demonstration of a hyperbolic relationship between size of measurement interval and number of measurements performed. Clearly, the ranges over which ocular components can be measured are dependent at most on the size of the eye itself and at least on the smallest anatomical components of the eye, i.e. the cells. In the case of retinal vasculature, the smallest component is the interval between vascular branching. Returning to the retinal capillary bed, firstly, retinal capillaries are not uniplanar[9] but form two lamellae throughout most of the retina and may form as many as four lamellae at the posterior pole (foveal avascular zone excluded). Conversely, larger retinal blood vessels approximate to a single lamina in the nerve fibre layer of the retina. Thus, fundus photography gives an accurate representation of the essentially planar distribution of larger vessels (at least at the posterior pole of the eye, which is relatively free from peripheral optical aberrations), but superimposes all levels of distribution of the capillary bed. As all estimates of fractal dimension to date have been performed on fundus photographs or fluorescein angiograms, this superimposition of capillaries would tend to overestimate their space-filling properties and lead to a falsely elevated value of D. The determination of fractal dimensions of geometric patterns filling a volume is complex and cannot, as yet, be applied to fundus photographs.

The second point is that capillaries are at the end of the size range of retinal vasculature with relatively uniform diameters and distance between bifurcations. One might, therefore, suspect that the retinal capillary bed, and indeed any capillary bed, is not a fractal, i.e. it is not statistically self-similar over a range of scales. If this is the case, the fractal dimension of a capillary bed is meaningless. Over what range was the determination of the fractal dimension quoted above estimated?

Whilst these points may appear trivial, they highlight the importance of interpreting any parameter in general, and fractal dimensions in particular, in the context of the phenomenon or pattern that they are measuring.

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Sir,

Drs. Misson, Landini and Murray express concern about 'a number of points' that 'require clarification' in my recently published cellular automata paper,[1] but discuss a single finding in my earlier article on the fractal properties