$\pm 1.75^\circ$ at $>15^\circ$. These figures are not comparable to average variability ranges of ± 2.6 – 5.6° at $<30^\circ$ found in numerous studies that have specifically endeavoured to perform the very best accuracy and reproducibility with automated and manual perimetry (static or kinetic) using skilled examiners and normal subjects.^{7–11} Even under these optimal conditions variability increases markedly past 30° and is in addition up to 50% worse in selected and experienced patients with various ocular pathologies.^{8,11} Non-selected patients will obviously have even greater variability.

Our greatest concern is with the potential artifact of compensatory eccentric fixation as caused by changes in head position during perimeter testing, thus incorrectly indicating field increases in particular areas, that is, the visually impaired hemifield in hemianopic patients. Patients are sufficiently intelligent to realise that they have been trying for days to enlarge their impaired hemifield area and that they are not trying to increase their normal visual field. This selective attention combined with relatively high interstimulus interval and unestablished head movements for any given trial are potentially independent and can easily cause the patient to unknowingly make different compensations that, as pointed out in our paper, may be undetected by the examiner. Furthermore, such an artifact would not be indicated by an abnormal location of the blind spot as mapped by the perimeter because during those test trials the patient would have no need to make such compensations, that is, he would have no reason to extend his blind spot. Similarly, it does not make sense that any of the above compensatory mechanisms would be used by either the patient or the therapist to reduce the patient's visual field. Compensatory mechanisms by the very definition, selectively favour alternative physiological mechanisms that are associated with desired change. Therefore we must still maintain that a bite-plate, as it is used in almost all of modern visual psychophysics, coupled with an eye monitor system, would eliminate the potential confounded variable of uncontrolled head movements and eccentric fixation.

Zihl and von Cramon believe that their exact training methods must be replicated and that such "an investigation depends critically upon the degree of correspondence with the [their] original study". This statement, however, is problematical. We would agree with Zihl and von Cramon's comments that our failure to find significant visual field increases with training could be

explained in terms of differences in patient groups, if they had used methods that were not potentially contaminated by artifacts. Until this is done, no conclusions about correlative brain mechanisms can be made.

This argument reminds us of the story about the horse named Hans that was reported by its owner to be able to count. As the story goes, people from many miles around came to watch "Clever Hans" correctly stomp his hoof on the ground in response to any verbally presented number. This was startling because other horses had previously not be able to count ... it seemed clear that this was a very special horse. The implication was that with proper training, perhaps, other horses might also be trained to count. Fortunately, someone eventually found that Hans' owner had unknowingly confounded results by slightly nodding his head just at the predicted moment that the animal was to stop stomping the ground. The fact of the matter was that Hans could not do the trick unless he was within visual proximity of his owner. It was never reported if Hans' owner objected when it was suggested that the conditions by which Hans had been evaluated should be changed. Hopefully, he was able to acknowledge the possibility of potential artifact.

We hope that Zihl and von Cramon will acknowledge the possibility of artifact. Until their training of hemianopic patients can be done under conditions where potentially confounded variables are eliminated or controlled, conclusions concerning correlative brain mechanisms cannot be considered as factual.

Regardless of whether or not one believes in visual field recovery and regardless of the method of training, the actual testing procedures that are used to measure results is crucial. Ideally, subjectively determined perimetry methods that are subject to bias should not be used. Instead we suggest standard automated perimetry presented in a pseudorandom temporal sequence that is automatically adjusted to reaction times. Under these conditions the monitoring of eye position would be essential and when combined with head stabilisation (for example, a bite-plate) the data would result in minimal error. The only exception to this would be the potential of inaccuracies in absolute foveal fixation on to the first trial of testing; all other trials would be relative to this point. In this manner the potential of visual field rehabilitation in the cortically blind could be objectively investigated.

References

- Balliet R, Blood KMT, Bach-y-Rita P. Visual field rehabilitation in the cortically blind? *J Neural Neurosurg Psychiatry* 1985;**48**: 1113–24.
- Zihl J. Recovery of visual functions in patients with cerebral blindness. *Exp Brain Res* 1981;**24**:159–69.
- Zihl J, von Cramon D. Restitution of visual function in patients with cerebral blindness. *J Neural Neurosurg Psychiatry* 1979;**42**: 312–22.
- Zihl J. "Blindsight": Turning a blind eye? *Science* 1983;**3**:468–9.
- Fankhauser F. Detection of scotomas by computer logic and by human search strategies. In: *Proceedings First International Meeting in Automated Perimetry System Octopus April 6/7*. Zurich: Interzeag AG Schlieren, 1979:130–48.
- Fankhauser F, Haerberlin H. An estimate of the falsifying effects of stray light in perimetry. *Doc Ophthalmol* 1980;**50**:143–67.
- Berry V, Drance SM, Wiggins RL. An evaluation of the differences between two observers plotting and measuring visual fields. *Can J Ophthalmol* 1986;**1**:297–300.
- Drance SM, Berry V, Hughes A. Studies in the reproducibility of visual field areas in normal and glaucomatous subjects. *Can J Ophthalmol* 1966;**1**:14–23.
- Bebie H, Fankhauser F, Spahr J. Static perimetry: accuracy and fluctuation. *Acta Ophthalmologica* 1976;**54**:339–48.
- Parrish RK, Shiffman J, Anderson DR. Static and kinetic visual field testing: reproducibility in normal volunteers. *Arch Ophthalmol* 1984;**102**:1497–502.
- Zingirain M, Gandolfo E, Capris P, Corallo G. Comparisons between static and kinetic threshold fluctuations determined by automated perimetry. *Documenta Ophthalmologica Proceedings Series* 1985;**42**:49–54.

Late responses as aids to diagnosis in peripheral neuropathy

Sir: In the process of establishing normal values for the F wave latency of the median nerve we consulted the study by Lachman *et al.*¹ Figure 1 of that paper is a regression line of F wave latency (ms) versus height in cms with lines of ± 2 standard errors drawn parallel to the regression line. The limits described are based on an erroneous calculation and cannot be used to determine the normal range for the F wave latency in a given individual. The limits within which 95% of F wave latencies in normal individuals would be expected to lie are given by

curved lines on either side of the linear regression.

The equation of the two curved lines is given by $Y \pm 2 \sqrt{\text{Var } Y}$ where Y is the predicted latency (from the regression equation) at a given height x and $\text{Var } Y$ is dependent on the x value.

$$\text{Var } Y = \text{MSR} \left[1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum(x - \bar{x})^2} \right]$$

with n as the sample size, x the given height and $\bar{x}$ the mean of the heights. MSR is the mean square deviation from regression and is given by

$$\text{MSR} = \frac{\sum(y - \bar{y})^2 - \frac{[\sum(x - \bar{x})(y - \bar{y})]^2}{\sum(x - \bar{x})^2}}{n - 2}$$

where y is the observed latency.

For 20 normal control subjects we obtained a regression equation F wave latency (ms) = 0.13 height (cm) + 6.1. The correlation coefficient for this relationship was $r = 0.601$ ($t = 3.187$, $DF = 18$, $p < 0.01$). The regression equation we obtained was similar to that of Lachman *et al.*¹ The regression line and 95% confidence limits are illustrated in the figure.

MICHAEL HUTCHINSON
Department of Neurology,
Adelaide and St Vincent's Hospital,
Elm Park, Dublin 4,
Ireland

LESLIE DALY,
Department of Community Medicine
and Epidemiology,
University College Dublin,
Ireland

Reference

- ¹ Lachman T, Shahani BT, Young RR. Late responses as aids to diagnosis in peripheral neuropathy. *J Neurol Neurosurg Psychiatry* 1980;43:156-62.

Wierzbicka, Shahani and Young reply:

As Hutchinson and Daly have pointed out, 95% confidence limits are generally represented as curved lines which reflect the growing uncertainty in any prediction made as x recedes from the centre of gravity ($\bar{x}$, $\bar{y}$) of the regression line. However, when n approaches infinity (that is, the number of observations is large), the 95% limits shrink to a strip of widths 1.96 SE ($\text{SE} = \text{standard error of the estimate}$).¹ Indeed, if one takes the formula for computing 95% confidence limits, $Y \pm 2 \sqrt{\text{Var } Y}$ used by Hutchinson

Fig Relationship of the F wave latency of the median nerve (ms) to height (cm) of normal subjects. The broken lines represent the 95% confidence limits.

and Daly and lets n approach infinity, one obtains:

$$a = \left[1 + \frac{1}{n} + \frac{(x - \bar{x})^2}{\sum(x - \bar{x})^2} \right] \rightarrow 1$$

$$\sqrt{\text{MSR}} \approx S_y \sqrt{1 - r^2} = \text{SE}$$

$$\sqrt{\text{Var } Y} = \sqrt{\text{MSR} \cdot [a]} = \text{SE}$$

where: r = correlation coefficient
 S_y = standard deviation of y

Thus the confidence limits shown in our figure which reflect $n = 124$ observations are an excellent approximation to the true confidence limits. The curved limits shown by Hutchinson and Daly are, of course, exact and differ somewhat from straight lines because they are computed from a smaller number of observations ($n = 20$).

In summary, as the number of observations upon which such a diagram is based increase, the 95% confidence limits become less curved and more nearly linear. After all is said and done, do Hutchinson and Daly suggest a "significant" number of those who attend nerve conduction laboratories are poorly served if these lines are not a little

curved? The routine use of late responses has certainly improved the utility of electrophysiological studies in individual patients with various neuropathies and the use of diagrams relating latency to height are clearly an improvement over earlier and more inexact techniques which attempted to measure conduction velocity. Nevertheless, these responses represent only one aspect, albeit a particularly precise and quantitative one, of the patient's overall evaluation and we believe it would be unwise to attempt to be artificially more precise about the boundary between normal and abnormal values than is warranted by the biological complexity of the system.

M MARE WIERZBICKA
BT SHAHANI
RR YOUNG
Department of Neurology,
Harvard Medical School,
Boston, MA 02114, USA

Reference

- ¹ Sachs L. *Applied Statistics, A Handbook of Techniques*. Berlin: Springer Verlag, 1984.