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CLINICAL INVESTIGATION

# Areas of the visual field important during reading in patients with glaucoma

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**Abstract**
*Purpose* To determine the areas of the binocular visual field (VF) associated with reading speed in glaucomatous patients with preserved visual acuity (VA).
*Materials and methods* Fifty-four patients with glaucoma (mean age ± standard deviation 70 ± 8 years) and 38 visually healthy controls (mean age 66 ± 9 years) had silent reading speeds measured using non-scrolling text on a computer setup. Participants completed three cognitive tests and tests of visual function, including the Humphrey 24-2 threshold VF test in each eye; the results were combined to produce binocular integrated VFs (IVFs). Regression analyses using the control group to correct for cognitive test scores, age and VA were conducted to obtain the IVF mean deviation (MD) and total deviation (TD) value from each IVF test location. Concordance between reading speed and TD, assessed using $R^2$ statistics, was ranked in order of importance to explore the parts of the IVF most likely to be linked with reading speed.
*Results* No significant association between IVF MD value and reading speed was observed ($p = 0.38$). Ranking individual thresholds indicated that the inferior left section of the IVF was most likely to be associated with reading speed.
*Conclusions* Certain regions of the binocular VF impairment may be associated with reading performance even in patients with preserved VA. The inferior left region of patient IVFs may be important for changing lines during reading.

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## Introduction

The conventional view of the functional impact of glaucoma is that it primarily disrupts peripheral vision. Yet difficulties with central vision, including seeing details and difficulty with reading, are consistently reported as problems experienced by patients with glaucoma [1]. Many questionnaire and self-report studies have found a link between glaucoma and problems with reading [2–10], but this has been corroborated by only a very few performance-based studies. One study, using performance-based measures taken from proficiency in a spectrum of activities, concludes that the reading of small print is one of the most visually demanding tasks for patients with glaucoma [11], while another indicates measured reading deficits in glaucoma are more apparent when letter contrast is reduced [12]. Still other studies show that measured reading speed deficits only occur in patients with advanced bilateral visual field (VF) loss [13] and that these deficits are heightened when sustained silent reading instead of out-loud reading is measured [14]. However, there is a large variability in observed reading speed in patients with glaucoma which cannot be well predicted by standard measures of visual function [15].

Links between measured visual acuity (VA) and reading performance are well established [16], but the relationship between VF loss and difficulty with reading is less well understood. It is likely, however, that VF defects very close to fixation will inhibit reading to a greater extent than VF defects in peripheral areas [17]. The results of a recent UK study with the aim to explore which parts of the binocular

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VF may correspond most closely with day-to-day difficulties in patients with visual impairment, including a small number of glaucomatous patients, suggest that the central 5° of the VF are particularly important in reading [18]. A study with a similar experimental design, conducted on glaucomatous patients from Japan, found the inferior left hemifield area of the binocular VF to be linked to patient response to questions about reading [19]. That study also found evidence to suggest that points in the peripheral superior hemifield may impact letters and sentence responses. These studies, however, used self-report measures rather than experimentally measured reading speed. Observations on visually healthy people with simulated VF loss suggest that damage to the inferior VF slows reading rates more than damage to the superior, nasal or temporal VF [20]. Further evidence suggests that the effects of VF loss on reading speed are likely to be independent of impaired VA: Ramulu et al. [14] found that patients had significantly slower reading speeds than controls when reading out-loud from a chart and from as near as desired, even though the latter task was a situation where impaired acuity should have theoretically have less impact. Moreover, Ishii et al. [21] found that reading performance of the Japanese version of the Minnesota Reading acuity chart was significantly reduced in Japanese glaucoma patients with good acuity relative to age-matched controls.

The aim of this study was to investigate how different areas of the binocular VF compare in their association to measured reading speeds in patients with glaucoma and preserved VA. This information would be clinically useful because it would facilitate a better understanding of which patients may have difficulty with this important everyday activity by interpreting their VF charts.

## Materials and methods

### Participants

Ninety-two participants between the ages of 50 and 80 years were recruited for the study, of whom 54 were patients diagnosed with bilateral glaucoma (Moorfields Eye Hospital Trust, London) and 38 were visually healthy age-related control subjects (City University London Optometry Clinic). All of the subjects ultimately enrolled in the control group underwent a complete optometric examination, including slit lamp investigation, before they were recruited. Patients had an established clinical diagnosis of primary open angle glaucoma in both eyes. Glaucomatous VF defects were defined as a glaucoma hemifield test (GHT) "outside normal limits" classification using the Humphrey field analyzer (HFA; Carl Zeiss, Meditec, Dublin, CA) at their most recent clinic visit. Participants were enrolled in the study only if they had a corrected binocular VA of $\geq$0.18 logMAR (Snellen equivalent 6/9) to minimise VA being a factor in the study. Astigmatic error was between $-2.5$ and $+2.5$ Dioptres in all those recruited. Patients had no ocular co-morbidities and were all graded as 'within normal limits' on the Oculus C-Quant straylight meter (Oculus GmbH, Wetzlar, Germany)—a surrogate measure for lens opacity. Recruitment was also restricted to those in good self-reported general health established by prior interview based on questions used on the EQ-5D instrument (euroQOL five dimensions questionnaire; [22]). Participants were not enrolled if they were on any significant medication other than that for their glaucoma. 'Significant medication' included anti-depressants or treatment for diabetes or use of β-blocker medication, all of which were deliberately mentioned to each participant. The recruited participants all spoke English as their first language or had been fluent in English for $\geq$10 years. The study was approved by a UK National Health Service, National Research Ethics Service committee and conformed to the Declaration of Helsinki. All participants gave their informed written consent prior to participation. All data were anonymised before being transferred to a secure computer database at City University London.

### Vision tests

Controls completed a HFA 24-2 SITA fast test in both eyes, and all were within normal limits in each eye, as defined by the GHT. Patients completed a HFA 24-2 SITA standard VF test in each eye, and their integrated VFs (IVFs) were calculated. IVFs are not a separate test, but combine monocular VFs with the assumption of perfect binocular alignment to estimate binocular fields of view through comparing each VF point for one eye with its corresponding VF point in the other and then selecting the better sensitivity value (Fig. 1) [23, 24]. In this instance IVFs were calculated using HFA total deviation (TD) values, which are the difference between the observed threshold and the age-corrected normal value at each VF testing point. The IVF calculations were performed using a purpose-written program written in the open-source environment R [25], which is freely available from the authors. IVF mean deviation (MD) values were calculated as weighted averages of the calculated TD values, with central points given a higher weighting than more peripheral areas; these weightings have previously been shown to correspond closely to those used by the HFA proprietary algorithms [24, 26]. Binocular VA was also measured with each participant's best correction in place using an Early Treatment Diabetic Retinopathy Study (ETDRS) chart with a uniform luminance of 120 cd/m$^2$, as recommended by the British Standards Institution.

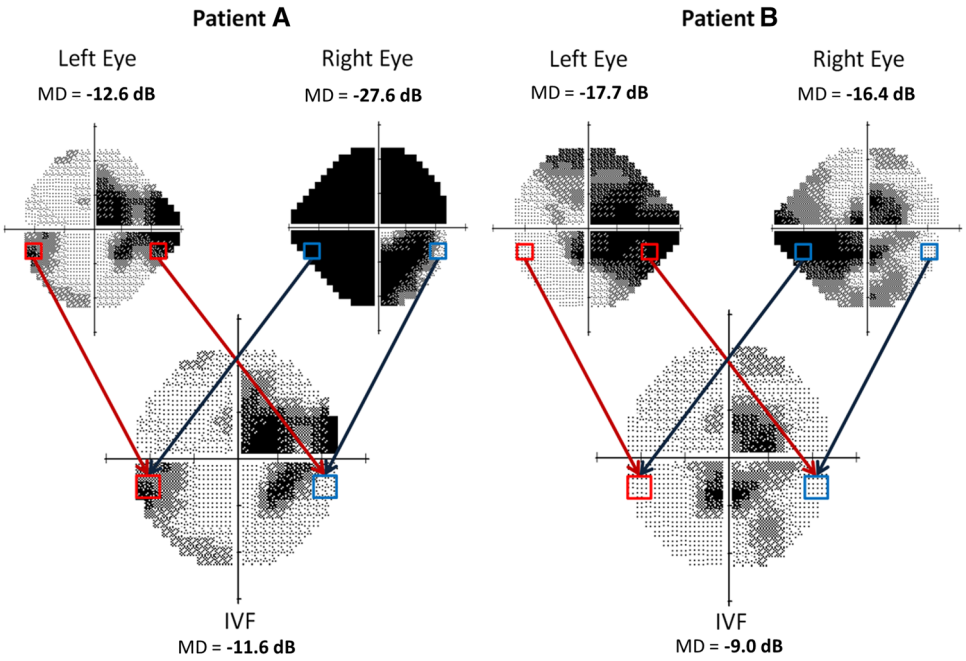


**Fig. 1** Calculation of the integrated visual field. Corresponding *points* in the *left* and *right* visual fields (VF) are compared, and that with the higher sensitivity is chosen to represent the integrated VF (*IVF*) for that point. The nasal steps are unique to each eye so these are not used in the calculation of IVF. The mean deviation (*MD*) value from the better eye can be very similar to the IVF MD value in many cases, as for patient A, but it can overestimate the severity of binocular damage in cases where damage between the eyes are asymmetric, as for patient B [26]

## Non-vision tests

In order to consider the non-vision influences on reading performance, which have previously been shown to be important [13], we utilised three measures, namely, the Burt Word Reading test (Scottish Council for Research in Education, Edinburgh, UK) (BURTS), the Middlesex Elderly Assessment of Mental State (MEAMS) (Pearson, London, UK) and a lexical decision task (LDT). These measures are described in detail elsewhere [12]. Briefly, the BURTS requires participants to read aloud words of increasing difficulty in a quiet, brightly lit room, the MEAMS involves completing a variety of cognitive tasks and the LDT requires participants to differentiate real words from false ones (e.g. "spoon" from "sploon"). As these tests all attempt to measure cognitive ability, we strived to combine the measures to arrive at a single "cognitive score" (C Score), and the numbers of errors made by each participant across all three of the non-vision tests were summed. In the case of missing data (two patients did not take the BURTS, one patient did not take the MEAMS and eight did not take the LDT), the numbers of errors were multiplied by 1.5 (or 3 in a single case where an individual only completed one test).

## Reading experiment

The reading material consisted of eight short paragraphs of text (68–79 words per paragraph, 5–7 lines per paragraph), adapted from an English fiction book. Each paragraph was presented one at a time in random order at 100 % contrast

**Fig. 2** The computer setup used during the reading experiment. The EyeLink 1000 eyetracking system was calibrated using the proprietary algorithm. A specified calibration accuracy of at least a "good" level (defined by the EyeLink software) was a prerequisite before each trial. Drift corrections were performed throughout experimental testing and, in cases where a large drift was detected, the subject was recalibrated before the study continued

on a 56-cm CRT computer monitor at a resolution of 1,600 × 1,200 with a refresh rate of 100 Hz (Iiyama Vision Master PRO 514; Iiyama Corp., Tokyo, Japan). Text was displayed in Arial font size 48, subtending 34 pixels on a screen, which equates to 0.84° (height) for the largest character. The letters were "black on white" with a background screen luminance of 33.4 cd/m$^2$ and a mean screen luminance of 0.05 cd/m$^2$. A table-mounted chin rest was used to maintain a 60-cm viewing distance (Fig. 2). All participants, even those without a distance or reading

prescription, wore the same set of trial frames with appropriate lenses to complete the study. This was to ensure that any restriction to the field of view as caused by the frames of the glasses was the same for all participants.

All texts were matched for readability (i.e. how easy/difficult they are to read) according to the Flesch–Kincaid measure [27], which gave the texts a measure of 8.2. Participants were given the same verbal instructions to: "…read the text silently, as quickly and accurately as possible" and "…confirm when they had reached the end of the passage". Once the participant indicated he/she had reached the end of the text, the supervisor pressed the escape button and the next text followed. The reading duration was measured retrospectively as the time from the first fixation on the first word to the last fixation on the final word using an EyeLink 1000 eyetracker (SR Research Ltd., Ottawa, ON, Canada). Participants were also periodically asked simple comprehension questions about the text to ensure they were on-task.

### Analysis

Reading speed in words per minute (wpm) for each of the eight trials was calculated by dividing the number of words read by the patient in any one trial by the reading duration of that trial. Overall average reading speed for each participant was calculated as the median of the eight values. Data from the controls were used to estimate the expected reading speeds of the patients in the absence of any VF defect, correcting for C Score, age and any residual VA differences. Data from controls were initially used to calculate coefficients representing the relationship between the C Score, age and VA and median reading speeds as shown in Eq. (1):

$$\begin{aligned}&\text{Control median reading speed (wpm)}\\&\quad = a + b \times (\text{Control C Score}) + c \times (\text{Control Age}) + d\\&\qquad \times (\text{Control VA}) \qquad (1)\end{aligned}$$

where $a$ through to $d$ are constants calculated through linear regression of control reading speeds against the C Score, age and VA. Following this, the calculated coefficients were used with the patient C Scores to calculate expected reading speeds for patients as shown in Eq. (2):

$$\begin{aligned}&\text{Expected reading speed (wpm)}\\&\quad = a + b \times (\text{Patient C Score}) + c \times (\text{Patient Age}) + d\\&\qquad \times (\text{Patient VA}) \qquad (2)\end{aligned}$$

The calculated expected reading speed obtained for each patient using Eq. (2) was then subtracted from the actual patient median reading speed to give a residual reading speed [Eq. (3)]. This residual reading speed represents the difference between a patient's measured reading speed and his/her hypothetical one given healthy VFs, thus giving an estimate of how much the VF loss contributes to reading performance.

$$\begin{aligned}&\text{Residual reading speed (wpm)}\\&\quad = \text{Patient median reading speed} - \text{Expected reading speed} \qquad (3)\end{aligned}$$

Following this, residual reading speed was then regressed against each VF variable to deduce the importance of that variable on the reading speed, as Eq. (4) demonstrates:

$$\text{Residual reading speed (wpm)} = e + f \times (\text{VF variable}) \qquad (4)$$

where $c$ and $d$ are the intercept and slope, respectively, calculated through regressing the calculated residual reading speeds in Eq. (3) against each chosen VF variable. Initially, median reading speed was compared with the calculated IVF MD values to investigate any general relationship between damage and reading speed. In order to assess which areas of the VF are most closely associated with reading speed, we subsequently conducted 52 separate analyses to obtain the TD value of each and every location in the IVF, using $R^2$ statistics, a measure of goodness of fit, extracted to assess how well reading speeds are explained by each IVF test point. The $R^2$ statistics approach was preferred over effect size because the latter can be heavily influenced by measurement variability. In other words, a high effect size does not necessarily reflect a high certainty that there is a stronger relationship between a test location and residual reading speed. On the other hand, a high $R^2$ value indicates a better fit between the model and data and, therefore, affords a greater level of certainty that a particular location in the IVF and the reading speed are linked. Nonetheless, it is still important to take effect size into account; a negative coefficient for the TD value in the regression models (implying a lower TD value is associated with higher reading speeds) is non-informative, so the $R^2$ statistics generated were multiplied by $-1$ in these instances. All test locations were then ranked by $R^2$ values from highest to lowest (1 being the most important test location and 52 being the least) to indicate which IVF points can most accurately model median reading speed. These ranks were then used to create a map corresponding to the areas in the IVF showing which areas were most likely to be associated with a reduction in reading speed. All statistical analyses were carried out in the open-source programming language *R* [25].

## Results

The characteristics of the study groups are given in Table 1. Women accounted for 55 % of the control group

**Table 1** Measured characteristics of the study groups

| Measured characteristics[a] | Patients ($n = 54$) | Controls ($n = 38$) | $p$ value[b] |
|---|---|---|---|
| Age (years) | 70 (64–77) | 66 (61–74) | 0.054• |
| Visual acuity (LogMAR) | 0.04 (−0.02 to 0.14) | −0.07 (−0.10 to 0.01) | <0.001*** |
| MEAMS errors (max score = 35) | 0 (0–1) | 0 (0–1) | 0.85 |
| BURTS errors (max score = 80) | 1 (1–2) | 1 (0–2) | 0.86 |
| LDT errors (max score = 30) | 1.0 (0–1) | 0.5 (0–1) | 0.66 |
| Cognitive score | 2 (1–4) | 3 (1–4) | 0.65 |
| Median reading speed (words per minute) | 273 (226–331) | 275 (230–318) | 0.88 |

Data are presented as the median with the interquartile range given in parenthesis

[a] Three measures were used to determine non-vision influences on reading performance: *BURTS* the Burt Word Reading test, *MEAMS* the Middlesex Elderly Assessment of Mental State, *LDT* a lexical decision task

[b] $p$ values were calculated using the Mann–Whitney $U$ test:

• $p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

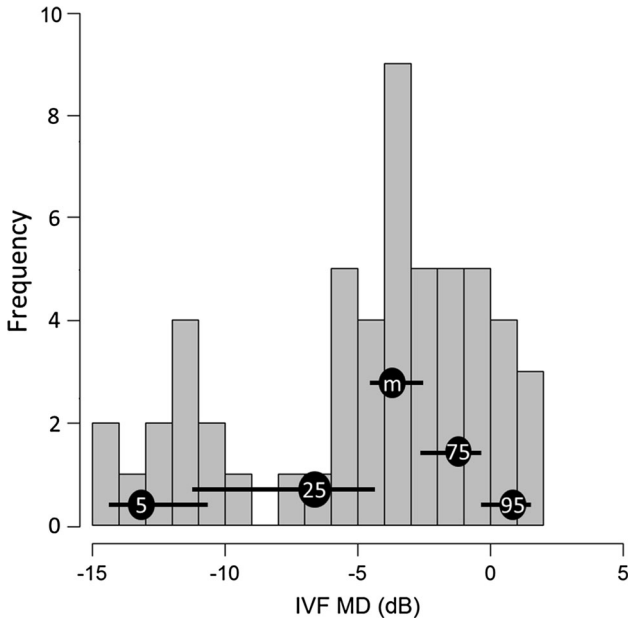


**Fig. 3** A histogram showing the distribution of IVF MD of participants in the study. *Numbers in black circles* IVF MD percentiles, *black horizontal bars* 95 % confidence intervals, *m* median

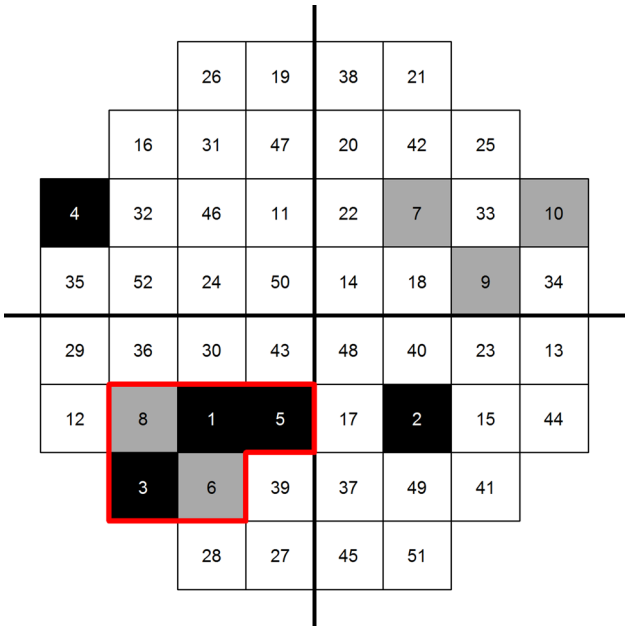


**Fig. 4** A map displaying each test location in the binocular IVF ranked by their respective $R^2$ statistics The total deviation value of each test location is fitted in a regression model against residual reading speed, adjusting for age, BURTS (Burt Word Reading test) score and visual acuity. *Black squares* ranks 1–5, *grey squares* ranks 6–10, *area bordered by red lines* region likely to be of greater importance than other sections of the VF when considering reading speed for patients in this study

and 50 % of the patient group. No significant differences in median reading speed between the control and patient groups were observed. The distribution of IVF MD values for patients in the study shows the majority of patients did not, however, have high levels of VF damage (Fig. 3).

The control model suggested that it accounted for 17 % of the variability in median reading speed in the control group ($R^2 = 0.17$). There was no significant association between IVF MD and patient residual reading speeds ($p = 0.38$). The ranking of test locations by $R^2$ statistics taken from regressing the 52 TD values against residual reading speeds seemed to suggest that the points more associated with reading speed tended to be clustered towards the inferior left of the IVF (Fig. 4). The central four points of the IVF, on the other hand, were among the least important points in terms of their relationship to residual reading speed. To investigate this further, the five conglomerate points ranked in the top 10 in this lower left region (Fig. 4) were summed and averaged to create a "region" variable before being fitted into a similar regression model to that utilised to assess the IVF MD [Eq. (4)]. This region variable only had a borderline

significant relationship with residual reading speed ($p = 0.07$), and the $R^2$ statistic for the model was low (0.06). However, the statistic was nonetheless over fourfold larger than the model using overall IVF MD ($R^2 = 0.01$). The low $R^2$ statistic indicates that neither the fit of the model for the region variable nor the IVF MD are sufficient for predicting patient residual reading speed and, therefore, true median reading speed. This, in turn, suggests that there are other more important variables influencing the observed reading speeds in the study that cannot be taken into account.

## Discussion

The aim of this study was to assess whether any areas of the binocular VF, as estimated by the IVF, could be linked with experimentally measured reading speed in patients with glaucoma in both eyes but preserved VA. The results suggest that an inferior left region of the IVF was most associated with the speed of reading in our patients with glaucoma. We speculate that the relative importance of this area may be due to this region of the binocular VF being used when locating a new line of text during reading; thus, VF loss may inhibit the ability to effectively bring new text into fixation. This explanation provides a plausible mechanism as to why some patients with glaucoma exhibit significantly slower reading speeds [13], especially during sustained reading. The notion that greater levels of VF loss are associated with greater self-reported difficulty finding the next line of text while reading (performing a return-sweep) has been investigated elsewhere with specific questions [28, 29]. In another study, Iester and Zingirian asked patients with glaucoma is if they "have trouble following a line of print or finding the next line when reading"; interestingly, 60 % of the patients who answered "yes" were shown to have a paracentral scotoma [30]. Furthermore, research shows that if the central vision is compromised, there is an advantage in eccentrically fixating during reading such that text falls in the inferior, rather than the superior, VF [31]. It is possible that the inferior area of the VF contributes to reading even in the case of healthy vision and that damage to this area may adversely affect reading as reported here, although we did not test this possibility.

The central four HFA VF test points covering the central 3° of the IVF were not shown to be strongly associated with reading speed. This was surprising given the findings of Tabrett and Lathan [18], who identified areas of the central binocular visual field which are important for daily functioning in the visually impaired, and the nature of reading (a task which requires the use of central vision). We suspect that our findings were a result of our study participants all having VA of $\geq$6/9 and that only a limited number of patients had central field loss in the central 3° of the VF. The central VF thresholds are highly correlated with VA, and this was not corrected for in the Tabrett and Lathan study [18]. We expect that if a greater range of patient VA had been used in our study (i.e. including VA of $<$0.18 LogMAR), our findings would have shown the central four points to be important. Certainly, research has shown that the single most important factor in low-vision reading is whether or not the central vision is intact [32] and that the maximum reading speed attainable in peripheral vision is lower than that in the fovea [17, 33]. In our study, average VA was slightly worse in the patient group than in the controls with healthy vision, and this difference was statistically significant. Yet, in the context of the large font size of the text used in the experiments, the average difference was negligible, equating to one line on the LogMAR chart.

Only one other study has previously considered the relationship between the locations of the binocular VF and reading performance, and the respective results between that study and the present one are interesting to consider [19]. Murata et al. [19] observed that the inferior field is the main area of importance for reading, much like the results of this research, but their region is closer to fixation. We speculate the fact that the participants in our study had better acuity (worse eye acuity was considered the best predictor of responses to reading questions in the Murata et al. study) and tended not to be very advanced in their condition may be causes for this inconsistency. The prominence of the superior left of the VF, apparent in the Murata study, was not observed in our study, while Murata et al. [19] found no indication of the inferior-left section of the VF being important. However, we theorise that this may be a result of the fact that reading in Japanese *tategaki* format goes from top-right to bottom-left rather than from top-left to bottom-right. It is known that the inferior paracentral points are important in Japanese reading [34]—in contrast to the right 5° of the VF in western countries [17]. Finding the next line in Japanese text would therefore require a saccade to the superior left instead of the inferior left, as in western cultures, which means that the results of our experimental study may in fact be consistent with the findings from Murata et al.'s research using self-reported reading measures.

It is important to note that our results only reveal associations and do not indicate that VF loss in the left inferior region can be used for directly predicting reading speeds. There are likely several reasons why a sufficient predictive effect was not observed in our study. Firstly, there was considerable variability between participants in experimental reading speeds, as reflected by the low $R^2$ values associated with the models fitted. This implies that

the relatively important reading region (or IVF MD) is not a major factor in determining overall reading speeds so long as VA is preserved under short reading durations—other attributes, undefined and more difficult to measure or account for, likely have a larger bearing on measured reading speed. Further, average reading speeds for the patient and control groups were not significantly different. This lack of a significant difference may be explained by the distribution of VF damage in our patient group (Fig. 3) in relation to the level of VF damage previously shown to be associated with slower reading speed in glaucoma [13]. For example, only a small number of patients (5/54) had IVF MD worse than −12 dB, and this is a likely average threshold at which most patients truly become noticeably functionally impaired [35–37]. The fact that certain areas of the IVF are more likely to be damaged than others early in the disease means that certain test locations have a wider range of sensitivities than others. For instance, substantially more of our patients had superior VF loss than inferior and central damage, which means that the trends found in the inferior hemifield are generally more dependent on fewer impaired test locations than the superior IVF locations. Giving more leverage to certain test thresholds can have a profound effect on the $R^2$ statistics calculated, and this certainly means that there is a higher likelihood that the rankings of the test locations in the IVF observed could be a result of chance.

There are other limitations to this study that warrant further discussion. The experimental setup was not representative of most day-to-day situations for reading. For instance, when not using a computer, individuals tend to read looking downwards rather than straight ahead which could well minimise the impact of inferior VF loss. In addition, the experimental setup using short passages of text with large font size did not reflect day-to-day reading where text size is usually smaller and text contrast more variable. It is likely that extending reading duration would have magnified differences between patients and controls given the findings of a recent study which established that reading speed decreases with reading duration more for patients than for controls, likely due to fatigue [14]. It is also important to recognise that this work may represent the "best case scenario" in reading performance for patients with glaucoma as poor readers are unlikely to volunteer to participate in reading research. Silent reading was chosen as opposed to out-loud reading for this study as the latter is determined by the ability to process the material read and to speak the words out-loud, while silent reading is limited only by the ability to (visually and cognitively) process the material. Out-loud reading can thus be limited by how fast an individual can, or is inclined to, speak; thus, a test of silent reading minimises the effect of this additional variable. It is therefore suspected that the impact of vision on reading is underestimated when reading out-loud [14]. Furthermore, silent reading is a more common task in everyday life than reading out-loud.

Our analysis of the relationship between VF loss and reading speed in the patients took advantage of the data collected on visually healthy people. This allowed for a estimation of corrected, or residual, reading speed, accounting for a measure of cognition and reading performance as measured by the MEAMS, BURTS and LDT scores; yet how closely these tests capture aspects of reading performance is questionable. These tests are simple and may be unable to detect the subtle cognitive demands used in reading. Additionally, we assumed that the probability of making a single mistake was equivalent across all tests, which may not be the case. The control group also allowed for a correction of individual differences in age and VA, although it is worth noting there was only a slight average difference between the ages of patients and controls in the study.

Further, measurements of monocular VF are vital for detecting and monitoring the progression of glaucoma in a clinical setting, but they do not always accurately reflect the true impairment of a patient [24]. There are other methods of representing the binocular vision of patients aside from the IVF [38], but the IVF has been shown to have good concordance with quality-of-life experiences of people with glaucoma [39], performance-based measures of visual disability [40, 41] as well as other binocular VF measurements [23, 42].

In conclusion, the results of this study suggest that the inferior left region of the binocular VF may have some relative importance in determining reading speed in patients with glaucoma in both eyes. We suggest that this region may be used to locate a new line of text during reading and that VF sensitivity loss in this area may in turn inhibit reading performance. There is no complete understanding of the relative importance of damage to different areas of the VF and how this damage might impact the patient with glaucoma. Therefore, more knowledge about the actual areas of VF loss that impact everyday activities would be clinically useful. Some VF metrics, such as the HFA visual field Index (VFI), have already been designed in attempts to reflect actual functional loss giving more weight to very central areas of the VF [43, 44]. Nevertheless, such global indices of the VF do not faithfully represent the spatial nature of VF defects in glaucoma and may therefore give a flawed representation of a patient's actual experience. The IVF utilised in this study is a potentially useful tool that is readily available from VF measurements routinely collected in the clinic and which allows for better estimations of binocular visual function [23, 24]. Our novel attempt at assessing which specific regions of the binocular visual field affect reading

performance should precipitate interest in this topic among many other activities that correspond with patient quality of life.

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**Conflicts of interest** R. Burton, None; L. J. Saunders, None; D. P. Crabb, None.

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