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# Blur point versus indistinguishable point in assessment of accommodation: objective and subjective findings in early presbyopes

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## Abstract

***Aim:* To measure the distance from the eye and the refraction of the eye at the point at which print blurs and the point at which it becomes unreadable.**

***Methods:* Subjective accommodation in 7 early presbyopic subjects (mean age 45 years), with no additional near correction, was tested using 6/12 reduced Snellen and 6/12 Lea symbols. The point at which blur was first noticed and the point at which the print became indistinguishable were noted in centimetres. Objective measures of refraction were taken at each of these points.**

***Results:* Subjective and objective results for reduced Snellen and Lea symbols were similar ($p = 0.91$; $p = 0.81$) as were the points where the print was no longer distinguishable ($p = 0.23$; $p = 0.72$). The difference between the blur point and the indistinguishable point measured in centimetres for both the reduced Snellen text and Lea symbols were statistically significant ($p = 0.005$; $p = 0.0001$). The objective measures for these points, however, were not statistically different ($p = 0.32$ and $p = 0.63$, respectively).**

***Conclusion:* A clinically significant difference exists in the distance from the eyes between the point at which text blurs and the point at which it becomes indistinguishable. No significant change occurs in accommodation when measured objectively after the blur point. It is recommended that the end point of this test is the point at which print starts to blur.**

**Key words:** Clinical testing, Objective accommodation, Presbyopia, Refraction, Subjective accommodation

## Introduction

Accommodation is commonly tested in the orthoptic clinic using the Royal Air Force (RAF) near point rule. The end point of the test may be either when the print becomes too blurred to read[1] or when it is first noticed that the letters are becoming blurred.[2] Further the patient may just be asked to say when the print becomes blurred.[3,4]

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Pollock[5] carried out a study to determine whether any difference existed between the point at which subjects were able to read print when text was being moved away from the eyes and the point at which print was too blurry to read as it approached. In 12 subjects with a mean age of 22 years (range 13–45 years), using N5 text, no differences were found for monocular or binocular testing.

Subjective assessment is limited by patient cooperation; however, Parkinson *et al.*[6] devised a method to perform subjective measurements of accommodation in children aged from 3 to 7 years old. They utilised a modified tape measure and Lea symbols, asking subjects to say 'stop' when the symbols could be named. The near-to-far method was chosen as young children do not have the cognitive maturity to understand the concept of blur and distinguishable point. This tool was compared with the RAF rule in a literate group of subjects, using the near-to-far method and asking for the point at which a clear image was noted. The literate group of subjects showed that the values obtained were similar with a good concordance correlation coefficient, and 87% of responses for the two devices differing by 2 cm or less. The authors concluded that the new tool was safe, effective, acceptable and comparable to the RAF rule for subjective measurements of accommodation.

Accommodation may also be assessed objectively, although this is not routinely performed in the clinic. Rutstein *et al.*[7] determine the amplitude of accommodation objectively with dynamic retinoscopy and subjectively in 57 patients (age range 6–35 years), finding high correlations but warning that individual examiners may tend to over- or under-estimate objective measurements. Objective measures of the change in refraction taken with an open field infrared optometer, such as the Canon R1 or Shin Nippon SRW autorefractor, are less likely to incur such error and have been shown to give reliable and similar measures in accommodation studies.[8,9]

When objective measurements of accommodation are being taken very small changes in accommodation can be recorded. Stark and Atchison[10] state that it is important to ensure that subjects are continually making the effort to accommodate. Their study showed that accommodation to the instructions 'carefully focus' or 'look at the words naturally' did not differ significantly from each other, but differed significantly from the instruction 'make no special effort'.

The purpose of this study was to compare objective and subjective measures of accommodation at the point at which blur was first appreciated and the point at which print was no longer readable for reduced Snellen letters and Lea symbols in presbyopic individuals. Any differences found may or may not be of clinical significance.

## Methods

The study was conducted using a repeated measures design where the independent variable was presented in a random order to the participants. Presbyopic volunteers from the Academic Unit of Ophthalmology and Orthoptics at the University of Sheffield were given an information sheet about the study outlining the purpose and testing procedures of the study. Inclusion criteria were: 6/6 or better corrected Snellen visual acuity; near visual acuity of 6/12 or better reduced Snellens in either eye without near correction at 50 cm and 33 cm; bifoveal binocular single vision on $4^{\Delta}$ base in and base out testing. Informed consent was obtained from the participants.

Objective measures of the refractive state of the eye were taken using the SRW 5000 autorefractor with the back vertex distance set at zero. Targets viewed by the participant were: 6/12 reduced Snellen letters (Clement Clarke fixation stick) and 6/12 Lea symbols. The Lea symbols were reproduced in the form of six lines of four symbols equivalent to 6/12 size.

Prior to commencing the test participants were given the instruction to 'carefully focus on the text and continue to make a conscious effort to ensure the text is clear', and were encouraged throughout testing to continue to do this. Any distance correction was worn throughout testing and measures were taken from the right eye only with both eyes open.

The first target was presented at 50 cm from the eye and moved towards the eye. The participant was asked to report when the print (text or symbols) appeared blurred. At this point the refraction was taken and a measurement of the distance from the nose was taken. The target was then moved further towards the nose, and the participant was asked to indicate where the print was no longer distinguishable; a further measurement of the refraction was taken and a measurement of the distance from the nose recorded. At each position three measurements of refraction were taken in rapid succession and without relaxation of accommodation between measures. Targets were presented to the participants in a random order.

All measurements were conducted in the same room, under the same lighting conditions, and at the same session. The SRW 5000 takes measures of refractive error to the nearest 0.12 DS and will compute the optimum value from a series of three readings. The mean spherical equivalent[11] of the optimum value was calculated by: Dioptre sphere + (Dioptre cylinder ÷ 2). Absolute changes in accommodation can be calculated by taking into account baseline refraction. However, as this study is comparing levels of accommodation between two targets or two points at close proximity this is unnecessary and actual refractive measurement is therefore used. Statistical analysis was performed using paired *t*-tests and the Pearson product-moment correlation.

## Results

Seven participants (6 women, 1 man; mean age 45 years, range 42–49 years) took part in the study. One participant (no. 7) reported the blur point but the target remained distinguishable to the limit at which the target could be moved in front of the SRW 5000 autorefractor. Therefore analysis could only be compared using the point at which the target was blurred in this subject. Table 1 shows the results obtained.

For subjective responses the position in centimetres at which the Lea symbols and reduced Snellens blurred were similar ($n = 7$; mean difference 0.1 cm, $p = 0.91$) and the points where the print was no longer distinguishable were also similar ($n = 6$; mean difference 2.18 cm, $p = 0.23$). A close correlation was also found for these measures ($r = 0.95$, $p = 0.004$ and $r = 0.81$, $p = 0.05$ respectively).

For objective measures, there was no statistical difference in the level of refraction at the blur point when viewing Lea symbols compared with reduced Snellens ($n = 7$; mean difference 0.02 D, $p = 0.81$) or when the print was no longer distinguishable ($n = 6$; mean difference 0.06 D, $p = 0.72$). A high level of correlation occurred in both circumstances ($r = 0.97$, $p = 0.002$ and $r = 0.83$, $p = 0.04$ respectively).

The difference between the blur point and the indistinguishable point measured in centimetres for the reduced Snellen text was statistically significant ($n = 6$;

**Table 1.** Centimetre and dioptric measurements for each subject

| Subject no. | Centimetre measurement (cm) | | | | Dioptric measurement MSE (D) | | | |
|---|---|---|---|---|---|---|---|---|
| | Rd Sn 6/12 | | Lea 6/12 | | Rd Sn 6/12 | | Lea 6/12 | |
| | Blur | X | Blur | X | Blur | X | Blur | X |
| 1 | 27.50 | 23.30 | 28.80 | 21.40 | 2.245 | 2.305 | 2.305 | 2.000 |
| 2 | 29.90 | 20.40 | 28.80 | 20.40 | 2.185 | 2.435 | 2.125 | 2.310 |
| 3 | 38.10 | 32.20 | 36.60 | 28.80 | 1.375 | 1.055 | 1.560 | 1.750 |
| 4 | 41.10 | 28.60 | 43.10 | 32.80 | 1.395 | 1.685 | 1.310 | 1.500 |
| 5 | 24.30 | 19.80 | 24.30 | 14.30 | 0.565 | 0.995 | 0.310 | 0.630 |
| 6 | 37.00 | 32.90 | 33.00 | 26.40 | 0.930 | 0.935 | 1.120 | 0.870 |
| 7 | 20.80 | – | 23.40 | – | 1.380 | – | 1.450 | – |
| Mean | 32.98 | 26.20 | 32.43 | 24.02 | 1.44 | 1.57 | 1.45 | 1.51 |
| ± SD | ±6.68 | ±5.83 | ±6.69 | ±6.63 | ±0.61 | ±0.68 | ±0.66 | ±0.65 |

Rd Sn, Reduced Snellen; Lea, Lea symbols; Blur, point at which print blurred; X, point at which print became unreadable; MSE, mean spherical equivalent; SD, standard deviation.

mean difference 6.8 cm, $p = 0.005$) as is the distance in centimetres between these two points for Lea symbols ($n = 6$; mean difference 8.42 cm, $p = 0.0001$). The objective measures for these points, however, are not statistically different (mean difference 0.12 D, $p = 0.32$ and mean difference 0.05 D, $p = 0.63$ respectively).

## Discussion

Accommodation is measured in the clinical situation using the smallest target size that is distinguishable[4] and it is acknowledged that some subjects in this study were able to see smaller print. Early presbyopic participants were chosen for this study due to there being a measurable difference between the blur point and the point at which the target is no longer distinguishable. Also they were considered as an available model for other groups where accommodation may be reduced. The nearest point at which a target could be presented on the SRW 5000 was approximately 13 cm because of the bulk of the casing for the wide view window, so this was a limiting factor. A 6/12 target (without presbyopic correction) was selected as it was necessary for subjects to see the target clearly but it does become more difficult to detect blur as an image size increases. Some subjects were able to see a smaller print (2 : 6/9; 1 : 6/6) and were tested with this. Results for these measures have not been presented here but the impression was that either target size could be used to produce comparable results of accommodation. However, this statement would need confirmation with further study.

The main aim of this study was to determine whether there was a difference in the end points of testing accommodation depending on the instructions given regarding level of blur and, if a difference existed, whether this was of clinical significance. A statistically significant difference was found in the measurement between the point at which blur was first noticed and the point where the print (text or symbols) was unreadable. The mean differences for reduced Snellen print and Lea symbols were 6.8 cm and 8.42 cm respectively, both of which we would consider clinically significant. Parkinson *et al.*[6] consider a difference of greater than 2 cm is of clinical significance.

The depth of focus of the eye varies with pupil diameter and target size[12] and may be defined as the range within which an image appears to have the same clarity and contrast. Subjective testing looks for an end point where blur is noticed, but this only occurs at the limit of the depth of focus. Depth of focus increases with decreasing pupil size.[12] Pupil size was not controlled in this experiment as this is not part of routine clinical testing. The objective measure of refraction gives the actual change in the lens power between the points at which blur is first noticed and where print is indistinguishable. In this study there was no significant change in refractive power between these points and thus although effort was made no further change in accommodation occurred after the blur point. For a linear distance change from the means of 32.98 cm to 26.2 cm, 0.785 D change in accommodation might be expected whereas only a 0.12 D change took place. If a larger number of subjects were studied, this difference might prove statistically significant; however, it would probably not be considered clinically significant. These findings would suggest that the better measure to record as the end point of the test is when blur is first detected. It certainly suggests that the end point should be clarified for different examiners in the same clinic in order that results are comparable from visit to visit for each individual patient.

Small dioptric changes in accommodation (measured in dioptres) are represented by smaller linear changes in the near point of accommodation (measured in centimetres) when that near point is close to the eyes than when it is remote. For example, a 1 D reduction in accommodation would reduce a near point of accommodation of 10 cm to 11.1 cm, or, a near point of 33.3 cm to 50 cm. Thus, the linear distance between the point where blur is first noticed and the indistinguishable point would be expected to be less where the near point of accommodation is closer to the eyes.

This study also examined the use of Lea symbols in place of Snellen letters. The results obtained suggest that 6/12 reduced Snellen and Lea symbols are comparable targets when measuring accommodation. This supports the results obtained by Parkinson *et al.*[6] who showed that a literate group of non-presbyopic subjects had a good concordance correlation coefficient when comparing subjective accommodation using the RAF rule and a modified tape measure using preliterate symbols.

Measurements were recorded from one eye whilst both eyes were open. Ramsdale[13] found that testing accommodation by introduction of lenses in the binocular and monocular situations produced essentially similar results, but further study would be needed before commenting on monocular testing of subjective accommodation. Also further investigation into this area may indicate whether similar findings would occur in the pre-presbyopic and younger age ranges, and in patients with accommodative problems.

We hope that these findings will help the clinician to make an informed decision on the end point of subjective accommodation testing.

## Conclusion

Measurements of accommodation using the reduced Snellen or Lea symbols of 6/12 target size are comparable. When assessing the near point of accommodation binocularly the end point should be stated, as a significant difference exists between the blur point and the point at which the target becomes indistinguishable. As no further change after the blur point was found on objective measures, it is suggested that the end point should be the point at which blur is first noticed.

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