Does fixation light intensity influence the results from the Sbisa bar when measuring sensory fusion?

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Abstract

Aim: **To determine whether the level of sensory fusion in normal participants is affected significantly by fixation light intensity.**
Methods: **Seventeen normal adult participants had sensory fusion measurements taken using the Sbisa bar, combined with Bagolini glasses, as a control for binocular single vision, whilst fixating lights of three different intensities: 150 lux, 250 lux and 350 lux. Data were analysed using Friedman's test and the Wilcoxon matched pairs signed ranks test.**
Results: **Seventeen participants were tested (mean 35.3 years, range 23–60 years). Friedman's test showed at least two of the light intensities had a statistically significant effect upon sensory fusion results ($p = 0.011$). Wilcoxon matched pairs signed rank testing found no statistically significant difference in levels of sensory fusion when fixating the 150 lux and 250 lux fixation lights ($p = 0.194$). There was a statistically significant difference in the level of sensory fusion when fixating the 150 lux and 350 lux lights ($p = 0.011$) and the 250 lux and 350 lux lights ($p = 0.017$).**
Conclusion: **Changing the intensity of the fixation light from 150 lux to 350 lux and from 250 lux to 350 lux significantly affected the level of sensory fusion measured. The higher the intensity of the light, the greater the filter needed to break fusion. The clinical significance of these results is considered.**

Key words: Bagolini filter bar, Bagolini glasses, Fixation light intensity, Sbisa bar, Sensory fusion

Introduction

The Sbisa bar or Bagolini filter bar is made up of 17 numbered red filters of increasing density in unequal steps. One of the uses of the Sbisa bar is to determine the strength of sensory fusion of an individual who has binocular single vision. It does so by ascertaining the level of dissociation required to disrupt sensory fusion.

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Sensory fusion can be defined as the ability to appreciate two similar images, one from each eye, and interpret them as one,[1] and is an important component of binocular single vision.

The use of the Sbisa bar, in conjunction with Bagolini glasses, as a sensory control for binocular single vision was first documented by Bagolini.[2] Knowles and Griffiths[3] found that combining the Sbisa bar with Bagolini glasses made the assessment of sensory fusion strength in normally sighted young adults easier to understand and interpret than using the Sbisa bar alone, without significantly altering the strength of sensory fusion. They advocated the method for clinical use and found the mean strength of filter needed to disrupt sensory fusion was 13.91 ($\pm$2.13). This was less than the original suggestion of Bagolini[4] that filter 16 or 17 would be required to disrupt normal binocular single vision. Hocking and Gage[5] also found a lower figure than Bagolini, with filter 11.01 ($\pm$3.37) being required, on average, to disrupt sensory fusion.

A number of confounding variables could affect the level of filter required to disrupt sensory fusion in clinical testing. Knowles and Griffiths[3] found no statistically significant difference in the level of filter required to disrupt sensory fusion when fixing with the dominant or non-dominant eye. Hocking and Gage[5] used the Sbisa bar to assess the strength of sensory fusion when fixating a light at both $\frac{1}{3}$ m and 6 m in a group of normally sighted young adults. Using 36 participants, they found that the mean strength of sensory fusion was 11.01 ($\pm$3.37) at $\frac{1}{3}$ m and 11.25 ($\pm$3.06) at 6 m, and these values were not significantly different. They therefore recommended that sensory fusion need only be tested at one fixation distance in a normal population.

Bagolini,[2] when describing the use of the Sbisa bar to measure sensory fusion in patients with exophoria prior to surgery, cautioned that the same conditions of illumination and fixation light intensity must be used in repeat measurements. Fixation light intensity does not appear to have been considered in previous studies, other than to ensure it was kept constant. The test is often repeated clinically from visit to visit by different practitioners and the brightness of the fixation light could be different each time. Nothing is known about how the results obtained from the Sbisa bar are affected if different fixation light intensities are used. The aim of this study was to determine whether the intensity of the

Fig. 1. Calibration of the light intensity using the lux meter mounted onto the synoptophore bulb's casing.

Fig. 2. The position of the light after calibration, with a participant looking through the Bagolini glasses and the Sbisa bar.

fixation light had any effect upon the levels of sensory fusion achieved, in a normal adult population, when measured with the Sbisa bar combined with Bagolini glasses as a control for binocular single vision.

Methods

This study was approved by the Sunderland Research Ethics Committee (reference number 07/H0904/91) on 27 November 2007. The research conforms to the provisions of the Declaration of Helsinki in 1995. All participants for the study were recruited following display of a poster in the Orthoptic Department of James Cook University Hospital. Prior to any testing, written informed consent was taken from all participants. The same equipment was used throughout the study and all measurements were taken by the same observer, in the same room, using the same lighting with no external light source from windows. The observer taking the measurement of sensory fusion was 'blind' to the fixation light intensity.

Sample size

Using data from Knowles and Griffiths,[3] the mean filter score was 13.91 with a standard deviation of 2.13. We shall assume that a clinically significant difference between filter scores would be at least two filters. Assuming that sensory fusion is normally distributed (although we accept that non-parametric tests are later performed on these data) and ignoring the paired nature of the data, a conservative estimate of the power of the study is given. In order to achieve 80% power with 95% confidence, 17 participants were required to detect a statistically significant difference between the fixation light intensities.

Inclusion criteria

The inclusion criteria to ensure a normal adult population with no pre-existing ocular abnormalities consisted of a minimum of Snellen visual acuity at $\frac{1}{3}$ m and 6 m of 6/6 right and left with refractive correction if required,

no manifest deviation detected on cover testing at $\frac{1}{3}$ m or 6 m, full ocular movements, bifoveal binocular single vision as shown by the 4 dioptre prism test (base-out and base-in) using the small house target on the Snellen stick at $\frac{1}{3}$ m, heterophoria of 10^{Δ} or less tested using the prism cover test measured at $\frac{1}{3}$ m using a 6/60 target on a reduced Snellen stick and age at least 18 years.

Procedure

A bulb attached to a rheostat on a synoptophore was used as the fixation light. The fixation light intensity was set and measured at three possible light intensities using a lux meter set at 6.5 cm from the light source. This was the distance from the lux meter to the bulb when fixed onto the synoptophore casing. Fig. 1 shows the calibration of the light intensities. The three light intensities chosen were 150 lux, 250 lux and 350 lux. A survey of clinically used torches had found variation in intensity from 184 to 286 lux, so these intensities were deemed to represent a relatively dull torch, a torch of average brightness and a very bright torch. The order of the presentation of the light intensities was randomised to reduce order effects. The first observer was 'blind' to the order in which the different light intensities were presented. The second observer set the first light intensity using the lux meter set at a fixed distance of 6.5 cm from the exposed bulb on the synoptophore, using the rheostat. The bulb was then rotated to the straight-ahead position so that it shone through a box, hiding its intensity from the first observer.

The participant was positioned $\frac{1}{3}$ m from the light looking through the Bagolini striated glasses (lorgnette type) and was asked to describe the position and number of lines visible. A patient with binocular single vision should see two oblique diagonal lines in an X shape with the fixation light in the centre. Fig. 2 shows the position of the light after calibration and the participant viewing the light through the Bagolini glasses and the Sbisa bar. If the two oblique lines were reported by the participant the Sbisa bar was introduced over the Bagolini glasses at the first filter by the first observer. The Sbisa bar was

Table 1. Sensory fusion measurements from the 17 participants using the three different fixation light intensities

Participant	Refractive error	Age (years)	Score from low intensity light			Median	Score from medium intensity light			Median	Score from high intensity light			Median
1		29	13	11	12	12	15	15	16	15	17	17	15	17
2		37	6	4	7	6	7	9	8	8	13	11	12	12
3	−1.00 −1.00	34	7	10	10	10	10	10	9	10	7	11	11	11
4		60	7	8	8	8	5	6	5	5	5	5	5	5
5		30	14	15	15	15	16	14	16	16	17	14	14	14
6		23	14	16	13	14	8	9	10	9	11	13	15	13
7	−2.00/+0.50 × 90 −2.75/+1.00 × 110	28	15	15	14	15	13	15	15	15	15	14	14	14
8		25	10	10	11	10	13	13	13	13	16	15	13	15
9	−3.25/+0.75 × 93 −3.75/+1.25 × 90	48	11	10	10	10	14	14	14	14	13	13	11	13
10	−5.25/+1.50 × 80 −5.25/+1.25 × 90	34	6	6	6	6	6	6	6	6	7	7	8	7
11		26	5	6	14	6	7	7	9	7	8	9	11	9
12	−1.00/+0.25 × 155 −1.25/+0.25 × 121	26	6	2	3	3	4	5	5	5	16	14	10	14
13		48	14	15	13	14	17	17	17	17	16	16	17	16
14		28	11	10	13	11	11	13	14	13	15	15	16	15
15		45	14	13	13	13	14	13	13	13	15	16	14	15
16		45	15	15	14	15	15	15	15	15	16	15	16	16
17		34	14	16	14	14	14	15	14	14	15	16	15	15
Overall median filter for each light intensity						11				13				14

placed over the right eye for all the trials. The participant was asked to confirm that the light had turned pink. The filters were then increased until a suppression response (one oblique line disappears) or diplopia response (two lights with one oblique white line passing through one light and one oblique red line passing through the other light) was reported by the participant. The participant was encouraged to regain sensory fusion when it was lost. The filter that produced either a diplopia or suppression response without recovery of sensory fusion was noted by the first observer and recorded by the second observer. Sensory fusion was measured twice more and a median reading from the three results was taken by the second observer. The second observer then set up the second light intensity and sensory fusion was measured three more times, the median reading being accepted as the result. The final light intensity was calibrated and sensory fusion measured three more times.

Results

Eighteen participants were recruited to the study. One participant had 6/9 vision in one eye and was excluded. The study sample, therefore, consisted of 17 participants with a mean age of 35.3 years (range 23–60 years). The median sensory fusion result from the Sbisa bar for the 150 lux light was 11 (range 3–16), for the 250 lux light was 13 (range 5–17) and for the 350 lux light was 14 (range 5–17). Table 1 shows the sensory fusion results for the different fixation light intensities for all 17 participants.

Friedman's test showed that at least two of the light intensities had a statistically significant effect on the results obtained from the Sbisa bar ($\chi^2 = 8.0$, $p = 0.011$). In order to identify which of the fixation light intensities were producing the differences in the sensory fusion measurements the Wilcoxon matched pairs signed ranks test was used. There was no statistically significant difference in levels of sensory fusion when fixating the 150 lux and 250 lux fixation lights ($p = 0.194$). There was a statistically significant difference in the level of sensory fusion between fixating the 150 lux and 350 lux lights ($p = 0.011$) and the 250 lux and 350 lux lights ($p = 0.017$).

The higher the fixation light intensity, the greater the filter required to disrupt sensory fusion in the majority of participants, with 65% of the participants showing their highest filter score with the 350 lux fixation light, the brightest fixation light.

Discussion

This study found that changing the intensity of the fixation light from 150 lux to 350 lux or from 250 lux to 350 lux, had a statistically significant effect upon sensory fusion measured using the Sbisa bar (combined with Bagolini glasses as a control) in a normal adult population. Whilst the results are statistically significant the clinical significance is uncertain. It was assumed in the sample size calculations that a filter difference of at least 2 would be required for clinical significance between filter scores. The group median filter scores for the three fixation light intensities tested were 11, 13 and 14. Whilst there is a difference of greater than 2 filters between the dullest and the brightest light, which could be considered of clinical significance, the difference between the medium and brightest fixation light is only 1 filter. It is possible that provided the light is 'bright enough,' no clinically significant difference in results may be achieved.

The median results from the Sbisa bar in this study

(11, 13 and 14) compare favourably with the findings of Hocking and Gage[5] and of Knowles and Griffiths,[3] who found the mean strength of sensory fusion at $\frac{1}{3}$ m to be 11.01 and 13.91, respectively.

The higher the fixation light intensity, the greater the filter required to disrupt sensory fusion in the majority of participants, with 65% of the participants showing their highest filter score with the 350 lux fixation light, the brightest fixation light. This is not surprising considering Weber's Law, which states that the ratio of the increment threshold to the background intensity is a constant. The higher the intensity, the greater an absolute difference needs to be before an effect is noticed; for example, in a bright environment a larger change in light intensity is needed for it to be noticed. When increment thresholds are measured on various intensity backgrounds, the thresholds increase in proportion to the background. Sensory fusion is possible with much greater differences of inter-ocular illumination (to a higher filter bar result) than is achieved with the dimmer fixation lights and thus less inter-ocular illumination difference.

Some of the participants, however, did not produce their highest filter results for the brightest light (for example participants 4 and 5). Participant 4 produced the highest median filter score when viewing the lowest intensity light (8) and median filter scores of 5 for both other light intensities. All these values are significantly lower than those normally expected, but the reason for this is not known. Participant 5 produced the highest median filter score when viewing the medium intensity light (16) and lowest median filter score (14) when viewing the highest intensity light. Reasons for this are also unknown, but the differences between these filter scores are 2 or less and may not be clinically significant.

The results of this study have clinical implications for the use of the Sbisa bar when testing sensory fusion in normal adults. It is important that the sensory status of the patient is monitored accurately and fusion measurements are comparable between clinical visits. As sensory fusion measurements appear to be sensitive to large changes in fixation light intensity, this study recommends that the intensity of the fixation light should be calibrated to an agreed 'bright intensity' before each use, in order to ensure accuracy of measurements.

The Sbisa bar is also commonly used to assess the density of suppression in patients with manifest strabismus and it would be interesting to investigate whether fixation light intensity affects the filter scores measured under these different circumstances.

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