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The repeatability of the Sbisa bar for testing density of suppression

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Abstract

Aim: **The density of suppression is often assessed in children undergoing amblyopia treatment. The purpose of this study was to assess the repeatability of the Sbisa bar to measure density of suppression by the same and different observers.**
Methods: **A prospective repeated measures study was performed on participants aged 5–16 years. Participants with constant suppression due to strabismus had the Sbisa bar test performed twice by one observer and once by a second observer with a period of 15 minutes between each test.**
Results: **Thirty participants were recruited with a mean age 7.3 years (range 5.1–15.1 years). Median filter value for the first test was 15 (interquartile range (IQR) 14–17), for the second test was 15 (IQR 13–17) and for the third test was 14 (IQR 13–17). Interclass correlation coefficient was 0.70 (95% CI 0.46 to 0.85) for the same observer and 0.73 (95% CI 0.44 to 0.87) for different observers. Inter-rater repeatability coefficient, *k*, was 0.32, SE 0.11 (95% CI 0.10 to 0.54). There was no correlation between the median filter value from the first observer's tests with age ($R = 0.08$), visual acuity in the amblyopic eye ($R = 0.01$) or visual acuity difference ($R = -0.01$).**
Conclusions: **The results show that in patients with suppression > filter 10 the Sbisa bar is repeatable within one to three filters when assessed by the same or different observers. There is no correlation between density of suppression and visual acuity or age.**

Key words: Bagolini filter bar, Repeatability, Sbisa bar, Suppression

Introduction

The Bagolini filter bar or Sbisa bar was developed by Bagolini in 1957 as a series of red filters in a ladder arrangement.[1] The Sbisa bar consists of 17 filters ranging from light pink (filter 1) to dark red (filter 17). It is used to investigate the density of suppression in patients prior to starting occlusion treatment for strabismic or mixed (a combination of strabismic and ansiometropic) amblyopia.[2–4] The aim of the test is to assess the risk of developing intractable diplopia due to a disruption of suppression. The Sbisa bar assesses the density of suppression at the diplopic point which should be receiving a similar image to the fovea of the fixing eye.

The density of suppression is quantified by placing the Sbisa bar in front of the patient's fixing (non-strabismic) eye and the filters are gradually increased; this reduces illumination to the fixing eye to induce diplopia or a fixation swap to the previously suppressing eye.[3]

In a retrospective audit[5] of the use of the Sbisa bar in 18 children (mean age 6.1 years, range 5.1–7.7 years) results indicated that the reliability of the Sbisa bar in predicting diplopia following amblyopia treatment is questionable. A comparison between patients who demonstrated diplopia during Sbisa bar testing and those who did not, showed that the age of onset of occlusion, duration of occlusion and starting visual acuity were not significantly different.[5] There have been no reports of correlation between age and density of suppression; however, it has been found that those reporting diplopia had a better initial visual acuity.[5,6]

A survey of 95 UK Head Orthoptists[7] found the Sbisa bar was used on patients of a median testing age of 6 years (range 2–8 years). Six per cent of responding departments reported that they did not use the Sbisa bar on any patients. No occurrences of intractable diplopia over a 5-year time period were reported by 91% of respondents. Of the 9% who reported cases, 6% reported one case, 2% two cases and 1% three cases. The risk of intractable diplopia was not discussed with parents prior to occlusion treatment by 8%, whilst 30% did not document advice given.[7] In large American studies[8] on the effectiveness of amblyopia treatment, density of suppression is not recorded and may not be considered by some clinicians to be reliable or an important factor.

There is limited literature to guide clinicians on the filter level that would indicate weak suppression and hence a risk of intractable diplopia if occlusion were commenced or continued. The reports in the literature as to which filter values trigger caution vary between 3 and 10.[7,9–12]

Aim

Currently there is little information available on the

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Table 1. Data for all 30 participants including median and interquartile ranges

ID	Age (yr)	RVA (logMAR)	LVA (logMAR)	Test 1	Test 2	Test 3	Devn	Suppn	O1 test 1	O1 test 2	O2 test
1	5.3	0.325	0.200	17	15	16	XT	R	17	15	16
2	5.1	0.000	0.200	13	16	14	ET	L	13	14	16
3	5.4	0.425	0.175	13	14	17	ET	R	14	17	13
4	5.1	0.425	0.000	17	17	17	ET	R	17	17	17
5	8.1	−0.050	0.800	15	17	17	ET	L	15	17	17
6	5.4	0.300	0.300	17	17	14	ET	L	17	17	14
7	8.1	0.350	0.100	17	17	17	ET	R	17	17	17
8	5.1	0.375	0.075	17	13	12	ET	R	17	12	13
9	6.5	0.175	1.050	15	14	12	XT	L	14	12	15
10	6.5	0.675	−0.100	14	14	14	ET	R	14	14	14
11	8.9	0.300	0.200	15	17	17	ET	R	15	17	17
12	7.4	0.075	0.450	17	17	17	ET	L	17	17	17
13	6.4	0.075	0.200	16	17	13	ET	L	16	17	13
14	5.2	0.550	0.000	17	14	16	ET	R	17	16	14
15	11.2	0.375	0.175	14	17	17	XT	R	17	17	14
16	5.1	0.725	0.075	14	14	14	ET	R	14	14	14
17	5.3	0.250	0.125	9	12	10	XT	R	9	10	12
18	5.3	0.550	0.025	12	11	12	ET	R	12	11	12
19	7.6	0.425	0.075	14	14	13	ET	R	14	14	13
20	9.5	0.425	0.000	14	16	16	ET	R	14	16	16
21	13.5	0.600	−0.100	7	9	9	XT	R	9	9	7
22	5.8	0.200	0.125	13	12	14	XT	R	12	14	13
23	5.8	0.250	0.050	17	14	14	XT	R	17	14	14
24	6.1	0.025	0.225	14	17	16	ET	L	14	17	16
25	7.1	0.100	0.050	12	7	5	ET	R	12	7	5
26	5.2	0.100	0.775	16	17	17	ET	L	16	17	17
27	6.2	0.250	0.625	15	13	13	XT	L	13	13	15
28	15.1	−0.100	1.000	17	17	17	XT	L	17	17	17
29	15.1	0.350	0.475	15	12	15	ET	L	15	15	12
30	5.5	0.075	0.275	15	17	14	ET	L	15	17	14
			Median	**15**	**15**	**14**			**15**	**16**	**14**
			IQR	**14–17**	**13–17**	**13–17**			**14–17**	**14–17**	**13–17**

RVA, right visual acuity; LVA, left visual acuity; Test 1, 2 or 3, the first, second or third Sbisa bar result, respectively, taken in each participant; Devn, type of deviation; ET, esotropia; XT, exotropia; Suppn, suppressing eye; R, right; L, left; O1 test 1, the first Sbisa bar results taken by O1; O1 test 2, the second Sbisa bar results taken by O1; O2, the Sbisa bar results taken by O2.

reliability and repeatability of the Sbisa bar for assessing density of suppression. This study aimed to provide clinicians information on the repeatability of the Sbisa bar so they can determine whether it is a useful clinical tool when managing children undergoing amblyopia treatment. If the test is not found to be repeatable, then it cannot be used in further research to determine its reliability in predicting the risk of diplopia.

Methods

Ethics approval

The project was sponsored by The Newcastle upon Tyne Hospitals NHS Foundation Trust. Ethics approval was sought and granted from the NRES Committee North East – Sunderland (REC reference 14/NE/0015).

Participants

Participants, age 5–16 years with constant manifest strabismus and suppression demonstrable with Bagolini Glasses for near and distance fixation, were recruited from current patients within the Orthoptic Department at the Newcastle Eye Centre. Those with alternating strabismus, visual loss due to other pathology or inability to perform a crowded logMAR visual acuity test were excluded from the study.

Design

This study followed a quantitative prospective repeated measures design. Observer 1 (O1) performed the Sbisa bar test twice and observer 2 (O2) performed the test once. The order of testing between observers was counter-balanced and planned prior to starting the assessment. Results from each observer were masked to reduce bias. Filter density was compared between and within observers, and in relation to age and visual acuity.

Procedures

O1 or O2 assessed visual acuity in each eye; they performed a cover test and Bagolini glasses at 33 cm and 6 m to confirm suppression. Patients were then assessed against the eligibility criteria. Informed consent was sought from the parent or guardian and older children (11–16 years) and assent sought from all younger participants.

Sbisa bar testing was performed by a standard procedure where the participant was asked to fixate on a spotlight held in primary position at 33 cm. The Sbisa bar was placed in front of the participant's fixing eye at filter 1 and the filters slowly increased at a rate of one filter per second. The participant was asked to state whether the light changed colour from pink to white or whether there were two lights (one pink and one white) seen as the filters were steadily increased. The observer noted the participant's subjective response and also made an objective assessment by recording any observed change in fixation. Results were recorded as the filter number prior to a switch in fixation and/or that at which diplopia was reported. The Sbisa bar test was repeated a further two times with a minimum break of 15 minutes between each of the three measurements, so that two measures were obtained from one observer (intra-observer) and one measurement from a second observer (inter-observer).

Results

Thirty participants were assessed with a mean age of 7.3 years (range 5.1–15.1 years). Twenty-one participants had a constant esotropia and 9 participants a constant exotropia. Eighteen participants had right eye suppression and 12 left.

Individual participant data are shown in Table 1. Twenty-seven participants had a density of suppression of greater than filter 10 on all three testing conditions, with 8 participants showing the three highest filters for density of suppression (filter values 15, 16 and 17). Three participants had a density of suppression of less than or equal to filter 10 on at least one testing condition. These 3 participants ranged in age from 5.4 years to 13.5 years.

Of these 3 participants with weaker suppression, 2 showed relatively stable low filter responses (participant 21 [7,9,9], participant 17 [9,12,10]), whilst the other participant appeared to have weakening suppression over the three tests (participant 25 [12,7,5]).

Fig. 1 shows the median density of suppression for all 30 participants as measured by each of the three Sbisa bar test observations in the order that data were collected. Test one had a median density of suppression of filter value 15 (interquartile range (IQR) 14–17); test two 15 (IQR 13–17); test three 14 (IQR 13–17).

Fig. 2 shows the maximum difference in filters recorded for the density of suppression between the three measurements taken. Differences between repeated tests ranged from zero to 7 filters (median 2, IQR 1–3).

Fig. 3 shows that inter-observer and intra-observer differences were small: O1 first test median = 15 (IQR 14–17), O1 second test median = 16 (IQR 14–17) and O2 median = 14 (IQR 13–16).

A Bland-Altman plot is shown in Fig. 4. The difference between O1's first and second test were small on average but show wide limits of agreement and repeatability (mean −0.03 (SD 1.96), levels of agreements +3.88 to −3.95, interclass correlation coefficient for single measure (one-rater) 0.70 (95% CI 0.46 to 0.85)).

When comparing O1 with O2 the first test result by O1 was used. A Bland-Altman plot (Fig. 5) between the O1 and O2 tests shows that differences were small on average but with wide limits of agreement and repeatability (mean +0.53 (SD 2.35), levels of agreements +5.22 to −4.16, interclass correlation coefficient for an average of measure (two raters) 0.74 (95% CI 0.44 to 0.87), inter-observer reliability coefficient $k = 0.32$ (SE = 0.11, 95% CI 0.10 to 0.54)).

In 36 of 90 separate Sbisa bar tests diplopia was observed subjectively as a response to disruption in suppression. The mean age of those reporting diplopia was 7.2 years (range 5.1–15.1 years), mean visual acuity difference was 0.313 logMAR (range 0.000–0.875) and median density of suppression was 14 (range 7–17).

A diplopia response was not observed subjectively in

Fig. 1. Box-and-whisker plot showing median, interquartile range, minimum and maximum value for each of the three tests in the order they were performed.

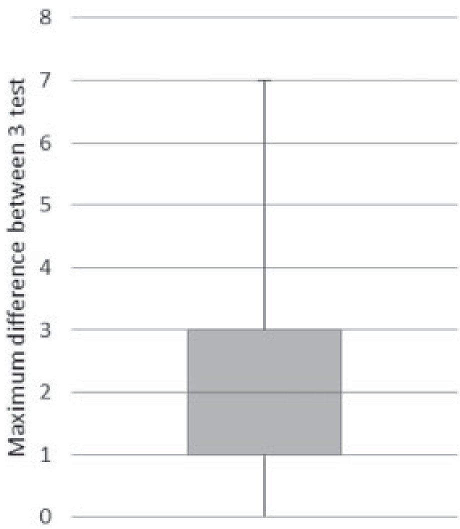

Fig. 2. Box-and-whisker plot showing median, interquartile range, minimum and maximum value for the maximum density of suppression filter difference for the three separate tests.

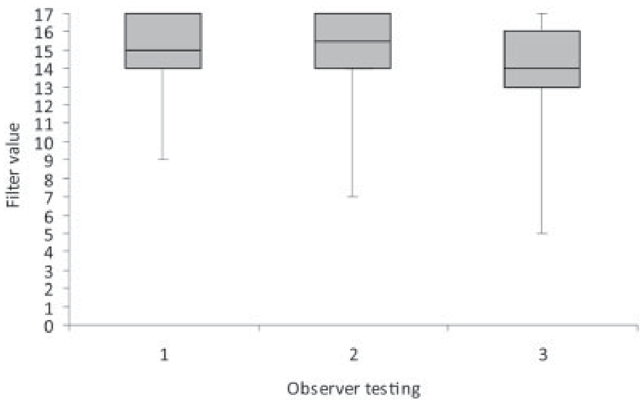

Fig. 3. Box-and-whisker plot showing median density of suppression, interquartile range, minimum and maximum value for O1's first test (1), O1's second test (2) and O2's test (3).

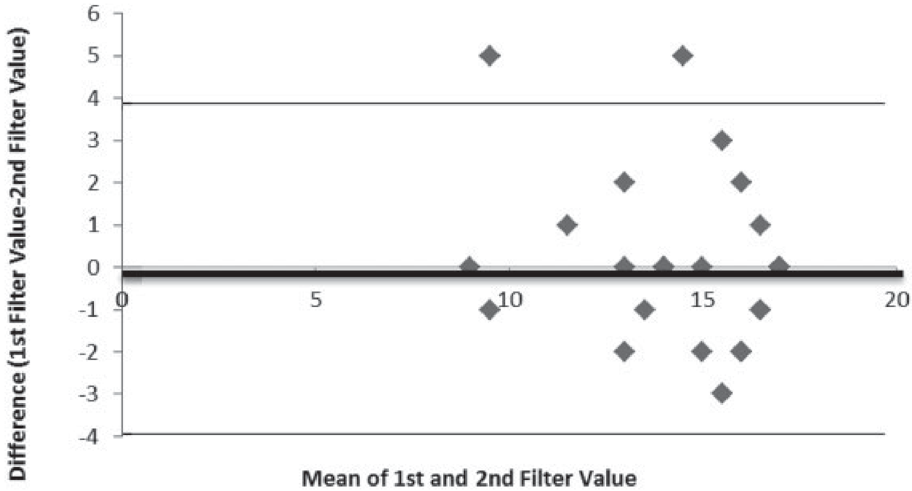

Fig. 4. Bland-Altman graph of O1's first and second test: mean −0.03 (middle line on graph), levels of agreement +3.88 (upper line on graph) to −3.95 (lower line on graph).

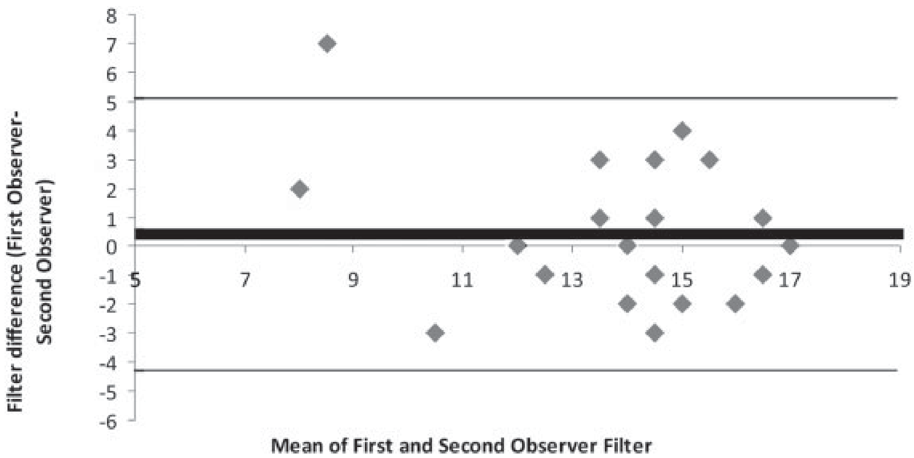

Fig. 5. Bland-Altman graph of O1's first test and O2's test: mean 0.53 (middle line on graph), levels of agreement +5.22 (upper line on graph) to −4.16 (lower line on graph).

all three tests by 9 participants. The mean age was 7.7 years (range 5.1–15.1 years), mean visual acuity difference was 0.488 logMAR (range 0.100–1.100) and median density of suppression was 17 (range 14–17).

Four participants (9, 17, 21 and 22) reported diplopia on all three tests. All these participants were exotropic, mean age 7.8 years (range 5.3–13.5 years), mean visual acuity difference 0.44 logMAR (range 0.08–0.88) and median density of suppression filter value was 12 (range 9–14).

To determine whether any factor was correlated with density of suppression a Spearman's rank correlation test was performed using the median filter value from O1's two tests to: age (Spearman's rank correlation, $R = 0.08$, $p = 0.69$, 95% CI for $R = -0.29$ to 0.43), visual acuity of amblyopic eye (Spearman's rank correlation, $R = 0.01$, $p = 0.95$, 95% CI for $R = -0.35$ to 0.37) and visual acuity difference (Spearman's rank correlation, $R = -0.01$, $p = 0.98$, 95% CI for $R = -0.37$ to 0.36). All three Spearman's rank correlation tests showed no correlation.

Discussion

Three separate assessments of the Sbisa bar on 30 participants were undertaken for the study. O1 completed two measurements, whilst O2 performed one. The results for each test in order (not specific to the observer testing) shows similar medians and interquartile ranges for density of suppression filter value; demonstrating that repeated testing did not lead to changes in the suppression density. There was a small difference in the number of participants showing an increase, decrease or the same density of suppression for their first and last test. There was one outlier (participant 25) who had a density of suppression difference of seven filters. The density of suppression filter difference over the tests showed a median value of two filters difference, with an interquartile range of one to three filters difference. The results showed that for different observers, similar median filter value and interquartile ranges are also produced, demonstrating the Sbisa bar is a repeatable test for assessing density of suppression when performed by the same or different observers.

The literature[9] suggests that if suppression is disrupted at filters 1 to 5 then patients are at risk of developing intractable diplopia. Only one participant (25) had disruption of suppression during testing within this range (filter 5) and was aware of diplopia when suppression broke down with the Sbisa bar but not in free space. Participant 25's results were the only ones to show a large decline over testing and could be classed as an outlier. It is possible that this variability is an indication of risk for development of intractable diplopia if occlusion were carried out, but more than one measurement would be required in a clinical situation to determine this variability.

Three participants in the study had a filter value for density of suppression of less than or equal to filter 10. There was no difference between these participants' inter-ocular visual acuity difference, visual acuity in the amblyopic eye or variability in the observers testing. From the literature review, filter 10 for density of suppression is the highest, deemed by some,[11] to be safe for commencing or continuing with occlusion treatment; however, responses to this question range from filter value 3[10] to 10.[11] In a survey of UK orthoptists[7] a minimum filter value of 7 for density of suppression was deemed safe to start or continue with occlusion treatment for amblyopia. From the results of this current study, only 2 participants obtained a filter value of less than or equal to 7 during testing However, these 2 participants show no difference compared with other participants as regards visual acuity in their amblyopic eye or visual acuity difference.

Previous research has made no comparison between density of suppression and age, but it has been reported that there is no correlation between density of suppression post-treatment and starting age for occlusion treatment.[5,6] The current study had a larger age range of participants, 5.1 years to 15.1 years, compared with 5.1 years to 7.7 years in a previous retrospective audit.[5] There was, however, no correlation found between density of suppression and age.

In contrast to previous studies[13,14] that have suggested a negative correlation between visual acuity and density of suppression, or those suggesting a positive correlation between visual acuity and suppression,[15] there was no correlation found in the current study between density of suppression and interocular visual acuity difference or visual acuity in the amblyopic eye. This current study had a large range of amblyopia compared with the previous work (0.000 to 1.100 logMAR). It is similar to the findings of a retrospective audit which found there was no correlation between visual acuity and the density of suppression when using the Sbisa bar.[5]

There were only 3 participants who had a density of suppression less than or equal to filter 10; therefore conclusions should be made from those demonstrating density of suppression of greater than filter 10 only. This study provides evidence to help prove the stability of suppression over three repeated tests on those with an initial response of greater than filter 10. However, due to the small number of participants with low filter values, further work is needed to look at the repeatability of the Sbisa bar to assess density of suppression in those with weak suppression of filter 10 or less.

Implications for practise and further research

This study did not set out to clarify previous work[9] into which filter value is clinically significant for predicting the risk of diplopia during occlusion treatment. It is evident from the literature review, however, that current practice is variable amongst clinicians and is not evidence based. A longitudinal study is now needed to follow children undergoing amblyopia treatment and assess their density of suppression and diplopia response at each visit. To compare treatments it should be undertaken on children undergoing different types of amblyopia treatment to determine whether atropine or conventional occlusion affects density of suppression similarly. It would then be possible to determine whether treatment plans should be adapted due to Sbisa bar responses; if so, at what filter level; and therefore whether the Sbisa bar is a worthwhile tool in clinic. Additionally a longitudinal observationally multicentre study is needed of patients with intractable diplopia to determine long-term changes, adaptation or resolution with time.

Conclusions

The study shows a significant change in filter value is 3 or more. Whilst there is small variability between tests this is not of clinical significance in terms of altering patient management decisions to stop amblyopia treatment. In patients with density less than filter 10 it may be advisable to use more than one measurement, but this needs further research on a larger study group with weak suppression to be conclusive.

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