Clinical and Experimental Optometry

ISSN: 0816-4622 (Print) 1444-0938 (Online) Journal homepage: www.tandfonline.com/journals/tceo20

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Amar Shah, Rachel F Pilling & J Margaret Woodhouse

To cite this article: Amar Shah, Rachel F Pilling & J Margaret Woodhouse (27 Aug 2025): The Bradford Visual Function Box can predict visual acuity in children who are hard to test, Clinical and Experimental Optometry, DOI: 10.1080/08164622.2025.2551749

To link to this article: https://doi.org/10.1080/08164622.2025.2551749

Published online: 27 Aug 2025.

CLINICAL AND EXPERIMENTAL OPTOMETRY
https://doi.org/10.1080/08164622.2025.2551749

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The Bradford Visual Function Box can predict visual acuity in children who are hard to test

Amar Shah[a], Rachel F Pilling[b] and J Margaret Woodhouse[a]

[a]School of Optometry & Vision Sciences, Cardiff University, Cardiff, UK; [b]School of Optometry & Vision Sciences, University of Bradford, Bradford, UK

ABSTRACT

Clinical relevance: Children with special educational needs can find it difficult to engage with traditional visual acuity testing methods; nonetheless, estimates of visual function are key to understanding how a child uses their vision for learning. Appreciating how functional vision testing relates to clinical scores is essential.

Background: The Bradford Visual Function Box (BVFB) has been shown to be useful in estimating visual function in children who cannot participate in standard acuity tests. How outcomes of the BVFB relate to clinical acuity scores has yet to be determined.

Methods: Retrospective clinical data of 79 children attending special schools were analysed, with particular attention to repeated visits over 7 years. At each visit, vision was awarded one of four classifications: normal, low vision, sight-impaired, and severely sight-impaired.

Results: Overall, 31 children were assessed with the BVFB on at least one occasion, of whom 16 went on to participate in a conventional test on a later occasion. Nine children achieved the same classification with a conventional test as with the BVFB, four were under-estimated by BVFB and three were over-estimated.

Conclusion: The BVFB is a useful tool to predict future visual potential of a child who has yet to develop skills to engage with formal acuity testing. Formal visual acuity testing should be pursued as the child develops as over time, as most children were able to engage with more complex testing regimes.

ARTICLE HISTORY
Received 28 October 2024
Revised 16 June 2025
Accepted 8 August 2025

KEYWORDS
Bradford Visual Function Box; BVFB; children; special schools; special educational needs; visual acuity

Introduction

It has been shown repeatedly that children with special educational needs/learning disabilities[1–3] are more likely to have a refractive error and/or visual impairment when compared to the broader paediatric cohort. The value of provision of eye care for children attending special schools has been recognised and both NHS England and Senedd Cymru (Welsh Parliament) are committed to developing a pathway.

Identifying the visual status of a child early in education has been demonstrated to have an impact on their ability to learn, either by the provision of visual aids or adaptations to the classroom setting.[4] Yet studies show that visual problems are often not recognised and not recorded in an education plan.[5]

The National Screening Committee guidance on vision screening[6] recognises that children within a special school setting should be 'offered a test appropriate for their developmental stage' and this would constitute a reasonable adjustment under the 2010 Equality Act. In reports of Donaldson et al. of outcomes of eye examinations for 949 children, despite the large range of visual acuity tests available, a reliable measure of visual acuity was only possible in 60.5% of the population.[2] It was noted that children with a diagnosis of autism were less likely to be able to participate in formal acuity testing than children with other diagnoses.

In contrast, a special schools scheme in Bradford reported success for 97% of their population using the Bradford Visual Function Box (BVFB) in addition to the usual conventional range of visual acuity tests.[7]

The BVFB (https://www.seeability.org/resources/bradford-visual-function-box) is a visual assessment test that allows assessment of visual function objectively in children who do not respond to traditional visual acuity tests. It comprises a selection of 10 small items of bright colour (beads, balls, silicone animals) or high contrast (black and white printed material) ranging in size from 4 to

CONTACT Rachel F Pilling r.f.pilling@bradford.ac.uk School of Optometry & Vision Sciences, University of Bradford, Bradford, UK

Table 1. Items included in the Bradford Visual Function Box.

Size of item (mm)	Fixation target description
4 mm	Seed bead
6 mm	Small bead
10 mm	Ridge bead
20 mm	Small flower bead
31 mm	Bauble
45 mm	Large flower bead
50 mm	Hedgehog
70 mm	Chicken
80 mm	Spiky ball
90 mm	Fan
120 mm	Black and white shapes book

120 mm, see Table 1). Each of the smaller items is attached to fine wire and can be presented in free space at a distance of approximately 30 cm. Therefore, any movement indicating that the child has perceived the object is taken as confirmation, e.g., fixing, following, reaching, or head-turning.

The current study aimed to examine the validity of BVFB in identifying visual (dys)function in a cohort of primary school age children with complex needs, in terms of its comparability with conventional tests.

Methods

The current study is a post-hoc analysis of longitudinal data from children attending special schools in Bradford, collected by an eye care team. Cross-sectional data have been published,[7] and the present study utilises follow-up data in a continuation of the scheme.

The population was a group of children attending a special school not previously under the care of the hospital eye service. The children were examined on a minimum of two and a maximum of five occasions over a period of 7 years (summer term 2012 to summer term 2019). The number of examinations was dependent on the completeness of the examination at each visit, the threshold of concern regarding undiagnosed visual impairment, the attendance of the child at the school setting on the days of site visits, and hospital eye service progress visits to monitor the impact of any intervention (e.g. spectacles) which had been advised.

Parents/carers were informed of an imminent visit by the eye care team and offered the opportunity to opt out of the programme. No parent did so in this cohort. The teacher informed the team of any underlying diagnosis pertinent to the child, e.g., ASD, hearing impairment.

A team of one orthoptist, one optometrist, and one ophthalmologist who have significant experience in examining this cohort conducted the assessments on-site at the respective schools of the child, and a familiar school staff member accompanied the child. Typically, each school setting would be visited three times during the school year, offering more than one opportunity for each child to be assessed.

Visual function or acuity was assessed using tests appropriate to the abilities of the child: BVFB, Cardiff Acuity Test, Kay Pictures (crowded and uncrowded), Keeler LogMAR crowded. If a child had spectacles, their vision was assessed using their habitual refractive correction. Only assessments taken binocularly were used for this analysis.

For the purposes of this study, the visual function outcome was graded according to the definitions used by UK eye professionals, aligning with the World Health Organisation terms, as shown in Table 2.[8] BVFB targets do not directly map to a visual acuity grading. It is longstanding local practice to interpret the results of BVFB assessment as shown in Table 2. In a special school setting strict standardisation of testing distance is not possible. It is commonplace to need to adjust the testing of a child to gain engagement and surmise the visual function of a child based on target size/testing distance.

The data were collated and analysed using SPSS (version 26). Additional functions such as non-cyclo refraction, dynamic retinoscopy, eye alignment, visual field and assessment of ocular media etc. were measured, but are not reported here.

Table 2. Table mapping equivalence between vision status, BVFB target size, and World Health Organisation visual impairment classification.

Vision Status	Target size at preferred distance, 30 cm	Definition	WHO Classification – Distance Vision Impairment
Normal	4-6 mm	Better than 6/18, or normal visual function based on observations in their habitual school environment.	Normal
Low Vision	10-45 mm	Worse than 6/18 but better than 6/60	Moderate
Sight Impaired	50-80 mm	Worse than 6/60 but better than 3/60	Severe
Severely Sight Impaired	90 mm or worse	Worse than 3/60	Blindness

BVFB Bradford Visual Function Box. WHO World Health Organisation.

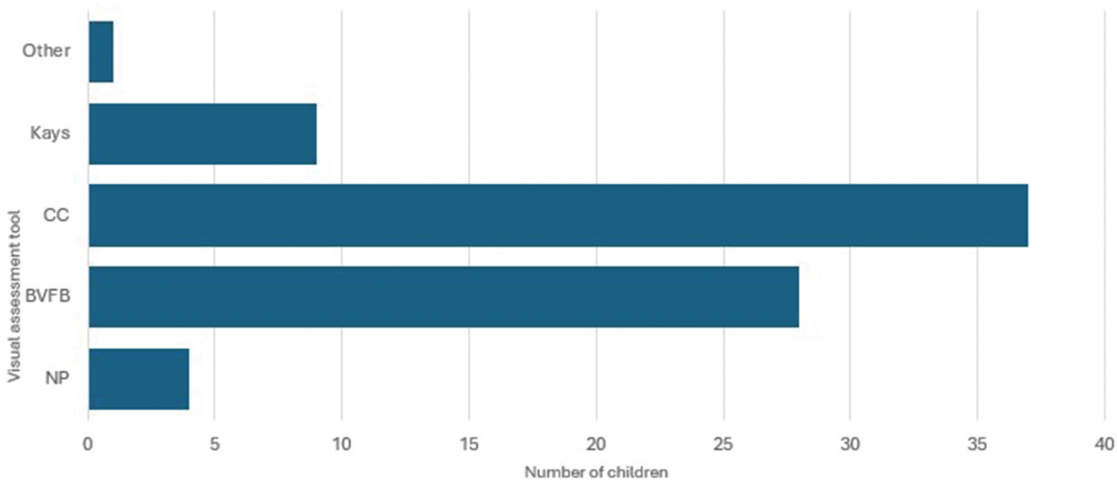

Figure 1. Methods of visual function assessment at the first examination incorporating all 79 children. BVFB – Bradford Visual Function Box; CC – Cardiff acuity test; Kays – Kay's Pictures; NP – Not Possible; other – the vision test used was not recorded.

Results

There were 79 children seen at the first visit, 25 (31.6%) of whom had a diagnosis of autism.

Figure 1 shows that a measure of visual function was achieved from most of the cohort (94.9%) at the first visit. Four cases were not successful with the visual function assessments. No vision test was attempted on one child because the vision of the child was limited to light perception, considered severely sight impaired.

Three of the children visually avoided the tests or simply did not wish to engage. Despite the children avoiding the test, the examiners observed the children in their habitual environment and spoke to their teacher about the activities of children in the classroom, leading the examiner to consider all three to have normal vision.[9]

The BVFB was used to assess vision in 36% of children with autism and 35.2% of children without autism. The Pearson's Chi-squared test showed no significant difference in test distribution between children with autism and those without autism ($p = 0.638$).

The majority of the cohort, 73.4% (58), were considered to have normal vision, 19% (15) had low vision, 5.1% (4) considered sight-impaired, and 2.5% (2) were severely sight impaired. All the children had a recorded vision status grading. Among the children who were assessed with the BVFB, 57.1% (16) were classified as normal vision, 28.6% (8) as low vision, and 14.3% (4) as sight impaired.

How well does BVFB predict vision status?

Longitudinally, 31 children used the BVFB on at least one occasion. For 15 children, the sole test used for visual assessment was BVFB 16 children also used a validated acuity test at one of their later visits, which allowed an evaluation of how well the BVFB can predict the future vision status of

Table 3. Vision grades for children progressing from BFVB to standard test.

BFVB grade, first visit	Grade at later visit	Comparison	Acuity test at later visit	Interval between visits	Notes
Normal	Normal	Equivalent grade	Cardiff	2 years	No spectacles
Normal	Normal		Cardiff	2 years	No spectacles
Normal	Normal		Cardiff	2 years	No spectacles
Normal	Normal		Cardiff	2 years	No spectacles
Normal	Normal		Cardiff	3 years	No spectacles
Normal	Normal		Cardiff	3 months	No spectacles
Normal	Normal		Kays	4 years	No spectacles
Normal	Normal		Kays	3 years	No spectacles
Low Vision	Low Vision		Cardiff	3 years	No specs at first visit, specs for myopia worn at later visit
Low Vision	Normal	BVFB underestimate	Cardiff	2 years	Spectacles not worn
Low Vision	Normal		Cardiff	2 years	No spectacles
Low Vision	Normal		Cardiff	2 years	No spectacles
Sight Imp	Low Vision		Not recorded	1 year	No spectacles
Normal	Low Vision	BVFB overestmate	Cardiff	3 years	Spectacles worn
Normal	Low Vision		Cardiff	4 years	No spectacles
Normal	Severe SI		Cardiff	3 years	No spectacles

BVFB Bradford Visual Function Box.

a child. For these 16 children, the vision status recorded using the BVFB was compared with the vision status recorded at the first of the subsequent visits when the child engaged with standardised acuity testing. Out of these 16 patients, nine had an equivalent vision status recorded with a validated acuity test.

Four patients were underestimated by one grade by BVFB, two were overestimated using BVFB by one grade and one was overestimated using BVFB by three grades. There were no refractive or ocular features recorded which might account for these discrepancies. The results are shown in Table 3.

Two of the patients who were examined with BVFB initially were later examined using Kays Pictures and the other 14 patients were later examined using the Cardiff Acuity Test. It is worth noting that two patients who were examined initially using another test had their acuity assessed using the BVFB at a subsequent visit with a comparable result. Test selection is guided by the engagement level of the child on the day. This suggests that the BVFB could be used interchangeably with standardised acuity tests if required and having a range of tests available offers the best chance of a successful assessment.

Discussion

In this study, with the inclusion of the BVFB a functional measure of vision was possible in almost 95% of participants. In contrast, SeeAbility found it was only possible to measure vision in 60% of their population. Donaldson et al., 2019[2] suggested that this may have been due to the lack of the BVFB in their range of tests, and, indeed the present study shows that a 35% improvement is accounted for by the BVFB. Donaldson et al. (2019) found that children with ASD were less likely to achieve a reliable acuity measurement with their tests. In the present study all of the children with autism managed to engage with testing, with over one-third using the BFVB.

A recent review of methods to assess visual function in children with complex needs where formal measure of acuity is not possible identified only three methods (visual evoked potentials, questionnaires and BVFB). The authors concluded that, BVFB can be useful as part of the assessment of vision where standard clinical tests were not possible.[10] The data we present in this paper go some way to providing additional validation of the BVFB as suggested by the authors.

The BVFB performed well in predicting future vision status. In three cases (of 16) the BFVB over-estimated vision and unfortunately this would have meant that the visual needs of children were not recognised, until a later date. However, in all other cases, vision was correctly identified, or under-estimated by one grade, which was unlikely to cause harm to the learning of the child. The success rate of BFVB was high, and if vision status within one grade is regarded as successful, BVFB can predict visual function with a success rate of 93.8%.

The professionals involved in this study each have experience in assessing and interpreting responses in children with complex needs. However, these skills are similar to those used in the assessment of infants and pre-verbal children and as such there is a short learning curve when adopting the BVFB as a tool.

The visual classification in this study refers to acuity in isolation, accepting that there are many other aspects to visual function which should be considered when describing the visual strengths and difficulties of a child. The BVFB may also play a role in the assessment of visual field, eye movements including tracking and refixation saccadic-type movements.

Strengths of this study are the same testing team for all assessments, in a real world testing environment, offering insights into day-to-day visual function. The group was heterogenous, with a range of ages and abilities, providing a cross section of children which an eye health specialist might expect to encounter as part of a special school visual assessment service.

It is noteworthy that for those children whose visual function at first assessment was over-estimated by the BVFB, there was 3–4 years between assessments. An obvious limitation of this study is that it was not possible to interrogate medical notes to understand if emerging ocular pathology could explain the discrepancy. The testing environment could not be standardised; deliberately so, because many children with SEN have variable visual attention based on sensory regulation and testers modify the approach to get the best from each child. Researchers had no access to medical notes to establish underlying cause of the neurodevelopmental deficit but were reliant upon teacher report of ASD.

Conclusions

In spite of the limitations and small scale of this study, the BVFB proved to be a useful tool to predict future visual potential of a child who has yet to develop skills to engage with formal acuity testing. The study also demonstrated that formal visual acuity testing should be pursued as the child develops over time, as most children were able to engage with more complex testing regimes.

Early identification of impaired visual function will enable earlier access to support for learning, so practitioners can rely on the BVFB when conventional testing is not possible, in confidence that the estimate of visual ability will likely prove correct.

Disclosure statement

Rachel F Pilling is co-creator of the Bradford Visual Function Box.

ORCID

Rachel F Pilling http://orcid.org/0000-0001-7191-8255
J Margaret Woodhouse http://orcid.org/0000-0002-7149-5077

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