FREE SPACE STEREOTESTS REVISITED

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Abstract
Despite a long history, free space stereotests have never found widespread acceptance. It is now becoming apparent that such stereotests do have a role to play in orthoptics. A new free space stereotest is described and evaluated.

Key Words
Free space stereotests, screeners, stereopsis, stereo-wedge.

To the majority of orthoptists, the evaluation of stereoscopic vision is an important aspect of patient management. In a recent survey of Australian orthoptists[1], 90 out of a total of 97 respondents rated the efficient evaluation of stereopsis as either important or very important. Many of the orthoptists, however, felt that there was a need for new tests to be developed and they gave suggestions as to the properties of such tests. The suggestions which occurred most frequently were that the tests be:

1. performed in free space to avoid test induced dissociation,
2. simple to use and hence easy to explain to patients,
3. able to give an indication of the patient's ability to use binocular depth perception in every-day activities,
4. suitable for mass screening applications, particularly with young children,
5. inexpensive,
6. free from significant learning effects.

It must be emphasised that any test which complies with these suggestions will be semi-quantitative at best, as it is impossible to eliminate monocular depth cues from free space tests. It appears that many orthoptists are willing to accept this disadvantage in order to make use of the advantages which are associated with free space tests.

Do any of the existing free space tests comply with all of the above criteria? Most of the traditional multi-rod tests (e.g. Helmholtz three pin test[2], Howard-Dolman test[3], Hering Dropping test[4]) are bulky and therefore not portable; this limits their usefulness as screeners. The results yielded by such tests have always proven difficult to interpret as they show little cross-correlation[5]. The tests generally require that the subject be trained before he can use them effectively[6]. While the Ames leaf room[7] appears to be very sensitive to the presence of "gross" stereopsis[8], its bulk prevents it from being used as a screener. The Verhoeff stereopter[9] is portable and thus is able to be used as a screener. Verhoeff deliberately introduced conflicting monocular depth cues to his test. The reasoning which led Verhoeff to introduce those cues has been questioned by Sloan and Altman [10]; they feel that "tests in which monocular and binocular clues are in opposition may give misleading information". This could particularly be the case when young patients are being tested, as they could easily become confused.

The only free space tests which are generally available are the Frisby test[11] and the Lang pen test[12]. The Frisby test complies with most of the above criteria but, as it is composed of random textures, it is difficult to explain to young or retarded patients. The Lang pen test appears to come closest to meeting the criteria. Because it involves the performance of a simple depth judgement task, it is actually giving a measure of the usefulness of the subject's binocular depth percep-

tion. The test is suitable for use with both adults and children, it is portable and involves negligible expense. It is therefore suitable for use as a screener. The test does have a very serious drawback: it relies on the examiner to make a subjective judgement of the patient's performance. For an examiner who has little or no binocular depth perception, this could prove very difficult. Under such conditions it is difficult to ensure than an examiner will give consistent performance estimates from one patient to the next. Despite these problems, the Pen test has the potential to become a very useful addition to the orthoptist's test array, it has therefore been used as the starting point in the development of a new "pen test". The new test, called the "Stereo Wedge", is illustrated in Figure 1. The device consists of two wedges whose apices are vertically aligned. Between the wedges is a scoring plane, which has a scale marked on it. The scale is calibrated in seconds of arc and reads 100, 200, 400 and 800 and 1600 sec. of arc on either side of the centre line. Because the test is intended to be used with children, a viewing distance of 1/3 metre was chosen.

How the Test is Used

The handle of the test unit is held horizontally and at right angles to the line of sight of the patient. The scoring plane is directed toward the patient in such a way that he is unable to make use of monocular cues. For example during binocular testing, the unit is aligned so that the plane points towards the eye which is on the side of the "writing hand".

The first trial is performed binocularly. The patient is asked to slowly bring a felt-tip pen in from the side and to touch the scoring surface of the test unit directly between the apices of the wedges. The patient's performance is read off the scale. If the mark is on the "patient side" of the zero line, the score is assigned a +ve value and if on the "examiner side" it is made -ve. The binocular trial is repeated at least once. If desired, the standard deviation of the trials can be calculated, as can an absolute mean (i.e. all scores treated as +ve). The binocular performance can then be compared with monocular performances by repeating the trials with right and/or left eye. The binocular performance should be both more consistent (less

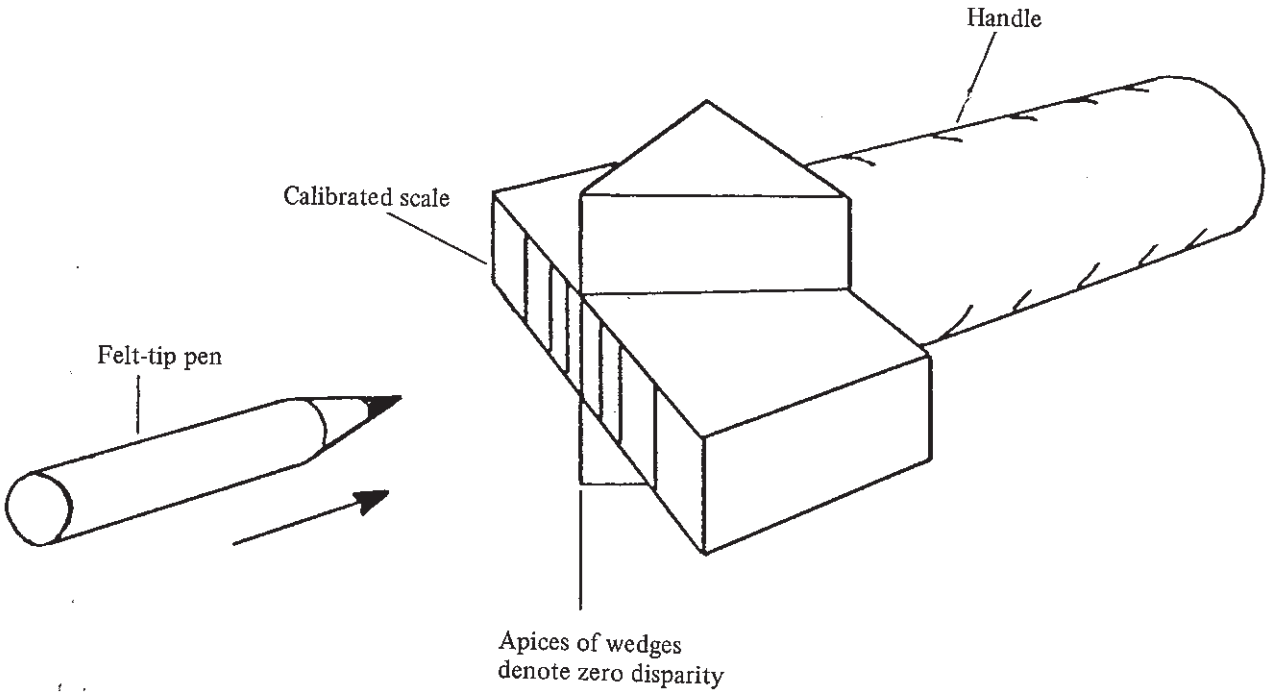

FIGURE 1 A schematic of the new pen test, the "Stereo Wedge"

spread or smaller standard deviation) and more accurate (consistently closer to the centre line, or smaller absolute mean) than either of the monocular trials. The binocular trials are performed first so that any improvement in performance, which occurs with practice, tends to reduce the difference between binocular and monocular trials. This should ensure that a significantly superior binocular performance is a result of the presence of useful stereopsis and not an experimental artifact.

The only precaution which must be taken is to ensure that the patient does not move his head. This precaution must be applied to all free space tests, as movement of the head introduces significant parallax cues.

A damp tissue is used to clean the scoring surface between each trial. The main reason for cleaning the surface regularly is to give the patient time to "forget" how far away the test is being held, this prevents him from using the length of his arm as a cue.

Evaluative Trial

A rigorous evaluative trial has been performed and will be discussed in statistical detail elsewhere[13]. In these experiments the patients attempted to mark the scoring plane, between the apices of the wedges, at least four times for each of the binocular, right eye and left eye trials. This allowed statistical analyses to be performed. Otherwise test methods were as described above.

Sixty-eight subjects participated in the evaluative trial. Each subject was categorised into one of five groups: normals (22 subjects), heterophores (22), convergent squints (14), divergent squints (5) and abnormal retinal correspondence (5). The subjects in the normal group each had normal or corrected to normal visual acuity and apparently full binocular function. All trials were carried out by, or under the supervision of, qualified orthoptists. Three clinics and one college participated in the project.

RESULTS

Consistency of binocular performances, as compared to monocular performances, was tested by performing an F-test comparison of the true binocular and monocular standard deviations. For the normal group, the spread of the binocular performances was significantly less than that of the best monocular performance in 86% of cases (5% significance level). For the other groups, the binocular spread was significantly less than the monocular spread in 42% of cases. However of all 68 subjects, only five (7%) had a monocular spread smaller than their binocular spread, and three of these had no demonstrable stereopsis. Clearly and particularly in the case of normal subjects, stereoscopic vision does give an advantage in depth estimation when considered in terms of consistency.

A convenient measure of the accuracy of a performance is the absolute mean score. If the binocular score is significantly better than both of the monocular scores, then the patient can be regarded as having useful stereopsis. If the absolute mean score of the best monocular performance was worse than the sum of the absolute binocular mean and standard deviation, the binocular performance was classed as significantly better than the monocular performance. The results yielded by the stereo wedge are compared with previous diagnoses in Table 1. There were a total of sixty subjects who had been diagnosed as having useful binocular vision. Fifty-four (90%) of these responded positively to the stereo wedge. This result is comparable to those reported by Hinchliffe[14] in her evaluation of the Frisby test and it is superior to those reported by her for the Wirt/Titmus and TNO tests.

Previous Diagnosis			Correct +ve.	False -ve.
Useful B.V.	Normal	(22)	20 (91%)	2 (9%)
	Het.	(22)	20 (91%)	2 (9%)
	Con.	(9)	7 (78%)	2 (22%)
	Div.	(4)	4 (100%)	0 (0%)
	A.R.C.	(3)	3 (100%)	0 (0%)
	Total	(60)	54 (90%)	6 (10%)
			Correct -ve.	False +ve.
No Useful B.V.	Con.	(5)	3 (60%)	2 (40%)
	Div.	(1)	1 (100%)	0 (0%)
	A.R.C.	(2)	1 (50%)	1 (50%)
	Total	(8)	5 (62.5%)	3 (37.5%)

TABLE 1 Comparison of the previous diagnosis with results of the Stereo Wedge Test

Of the eight subjects who had previously been diagnosed as having no useful binocular vision, three yielded significantly superior binocular performances. While they have been referred to as "false positives" in Table 1, it appears more likely that they do in fact possess some form of useful stereopsis (probably coarse[15]) which has previously been undetected.

Overall Group Performances

The overall performance of the normal group was compared with those of the heterophore and squint groups. The results for the three groups complied reasonably well with expectations. The binocular performance of the normal group was the best, the heterophore group also performed well and both of these groups performed better than the squint group on binocular trials. Monocular performances for the three groups were quite consistent. This is in agreement with the results reported by Henson and Williams[16], who also found no difference between monocular performances of normal and strabismic subjects.

As a rule of thumb, it seems that if a patient can average better than about 250 seconds of arc absolute mean binocular performance on the stereo wedge, then he probably has quite useful stereoscopic vision.

Discussion

The results of the evaluative trial indicate that certain patients, who have poor visual acuity and a weak hold on their fusion, may still have useful stereoscopic vision. Such patients will often be falsely diagnosed as having no stereopsis by contemporary stereotests. The haploscopic tests will sometimes prove dissociative and even if they do not the fine texture used in many of the tests will limit their usefulness with these patients. Where such a patient is encountered, the stereo wedge test can prove very useful in indicating whether the patient has any residual coarse stereopsis.

Another area in which the stereo wedge may be useful, is as a demonstration to the parents of young patients of the importance of maintaining useful stereopsis. If the parent has a correct perspective on the motivation behind treatment, he or she is in a better position to encourage and support the young patient.

In conclusion, it is apparent that there is still a place for the free space testing of stereopsis. One such test, the stereo wedge, would appear to be particularly suitable for use both in the clinic and as a general screener.

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