Original Evidence Based Scientific Article

Assessment Of Adult Stereopsis Using The Lang 1 Stereotest: A Pilot Study

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ABSTRACT: ***Background and Purpose:*** To assess the use of the Lang 1 Stereotest as a vision-screening test for adults, for which little is known or reported.

Method: The Lang 1 Stereotest was administered to 292 consecutive participants of the Visual Impairment Project (VIP) five year followup study, which is a population based study of eye disease in Melbourne, Australia. 56.9% were female. The mean age was 59.4 years, range 44-90 years. A "positive" stereoscopic response was recorded where the stereoscopic target image was correctly named; a "partial positive" response where depth was appreciated but the shape could not be named; and a "negative" response where there was no appreciation of a stereo effect. The responses were further categorized so that the test was either "passed" or "failed". A "pass" score was 3/3 positive responses; 3/3 partial positive responses or 2/3 positive and/or partial positive responses where the negative response was at the 550" of arc stereoacuity level. "Failure" was 3/3 negative responses and 2/3 negative responses where the positive or partial positive response as at the 1200" level.

Results: Of the 292 participants tested, 19 (6.5%) participants "failed" the test. In addition to strabismus and anisometropia, failure was associated significantly ($p < 0.001$) with reduced distance visual acuity (<6/12) irrespective of the ocular morbidity.

Conclusion: The Lang 1 Stereotest correctly identified people with vision defects associated with reduced stereopsis. This suggests the Lang 1 Stereotest is an appropriate for the vision screening of adults as it is for children.

Key Words: amblyopia, functional; binocular vision; Lang 1 Stereotest; prospective study; stereopsis, adult; study, prospective, pilot; screening, vision; stereotesting; strabismus; vision, adult, screening.

Abstract Translated into Spanish, French and German at the end of this article.

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INTRODUCTION

Elderly car drivers with minimally reduced visual acuity (6/12 to 6/15), plus reduced stereopsis may be moderately more at risk of involvement in an automobile accident than people with reduced visual acuity alone (1). Also, stereoacuity is an objective indicator of functional improvement following unilateral cataract surgery (2), and that there is a quality of life benefit from second eye surgery in cataract cases where stereopsis is restored (3).

All these results suggest loss of stereopsis may adversely impact on the quality of life of older persons. This is of particular concern as older people are increasingly at risk of having impaired vision due to age related eye diseases(4).

In addition to the known risk factors of strabismus and amblyopia, reduced visual acuity (5,6), anisometropia (7), optic nerve disorders (8) and glaucoma (9,10) have been associated with reduced stereopsis in adults. There is also some evidence that stereopsis decreases with age (11-15).

The Lang 1 Stereotest (Figure) is an effective childhood screening test for defects of binocular vision (16-18). The test consists of one plate that makes it quick to administer; no additional spectacles are needed; and there are less monocular clues than other stereotests.

No normative data are available on the use of the Lang 1 Stereotest with an adult population.

The aims of this pilot study were to evaluate the use of the test in an adult population, to assess the factors associated with failing the test, and to obtain normative data for the test in this population.

SUBJECTS & METHODS

This pilot study was part of the five year followup study of the Melbourne (Australia) Visual Impairment Project (VIP), a population based study of eye disease in an adult population age 40 years and older, conducted initially from 1992-1994. The VIP protocol has been described in detail elsewhere (19).

Briefly, after obtaining consent, a detailed ophthalmic examination was conducted on 2465 participants (85% of eligible baseline participants).

Data were collected through a standardized interview regarding sociodemographic characteristics that included the language spoken at home and the country of birth of the participants and of their parents. Each participant's unilateral (monocular) visual acuity was measured while wearing their current distance correction. The visual acuity test was a 5 letter LogMAR chart. The acuity test distance was 4 m. Binocular near visual acuity was measured using the LogMAR word reading card. A near correction was worn if the participant normally used it. Cover/uncover testing was performed at near (30 cm) and distance (6 m) fixation. Following pupil dilation each participant had a slit lamp examination, indirect ophthalmoscopy and lens and retinal photography.

The VIP was not designed to investigate ocular motility in detail and the protocol did not include any test of binocular function. But after preliminary results of the followup study (20) indicated the prevalence of acquired strabismus (including constant and intermittent deviations) was approximately 7%, it was recognized that a significant number of participants may have defective stereopsis when risk factors, in addition to strabismus, were investigated.
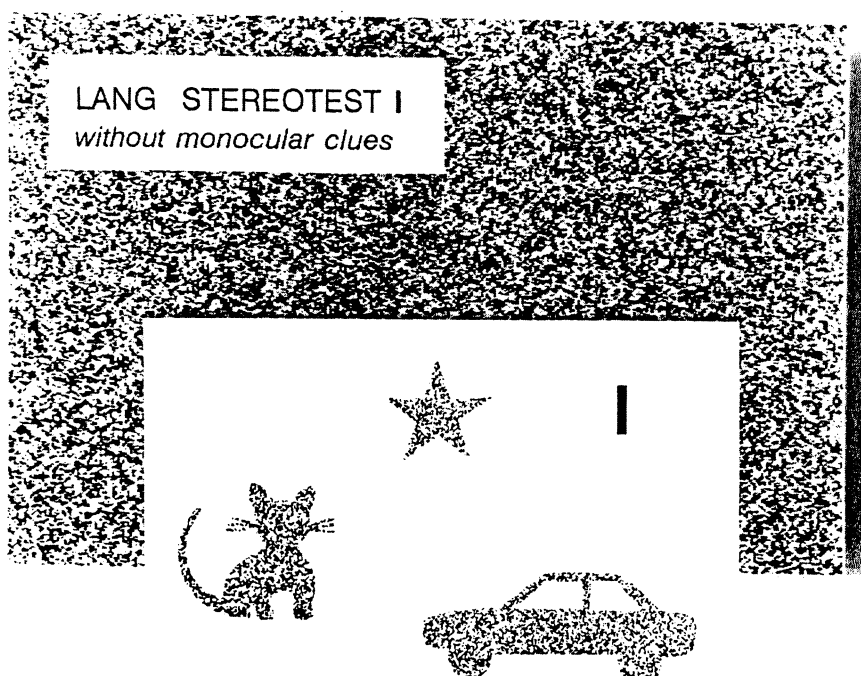
The Lang 1 Stereotest was therefore included in the protocol and was administered to the final 292 VIP participants and it is these participants that are the subjects of this study.

The mean age of the participants was 59.4 years (SD=10.4; range 44-90 years). There were 166 females (56.9%). One hundred and thirty participants (44.5%) were born outside Australia and of them, 37 did not speak English at home. This sample group had the same demographic characteristics as the VIP participants overall (4,19,23).

The Lang 1 Stereotest (Figure) is based on the principles of random dots and cylinder gratings. In the test, a cat, star and a car are seen stereoscopically on a flat screen measuring 9.5 cm x 14.5 cm. At a distance of 40 cm, the cat represents a retinal disparity of the stereo targets of 1200" (seconds of arc) the star, 600" and the car, 550" (21).

Each participant's stereopsis was assessed while they wore their near correction. The test was held at the normal reading distance, approximately 40 cm. (Not holding the test at precisely the prescribed 40 cm distance from the face was not considered to invalidate the test results as this study was not designed to assess precise levels of stereoacuity, but to assess

LANG STEREOTEST I
without monocular clues

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normal values when the test was presented in a screening situation.)

Participants were asked to identify any shapes observed on the Lang card. A positive stereoscopic response was recorded where the participant correctly named the shape and negative where the participant did not appreciate a stereo effect. There were a number of participants whose response indicated they appreciated depth but they were unable to correctly name the shape. According to Lang (22), these participants may be scored as having a positive recognition of stereopsis. Thus, we defined these responses as partial positive responses.

In order to examine the factors associated with defective stereopsis, the responses were categorized so that the test was either passed or failed (Table 1). To pass the test, a participant had to score 3/3 positive responses, 3/3 partial positive responses, or 2/3 positive and/or partial positive responses where the negative response was at the 550" level. A participant failed the test where there were 3/3 negative responses and 2/3 negative responses where the single positive or partial positive response was at the 1200" level.

[Functional] amblyopia was defined as a reduction of best corrected visual acuity of ≤6/9 in the amblyopic eye, with at least one line difference between the two eyes and with no pathological or refractive cause for the reduced visual acuity. Anisometropia was defined as ≥1 Diopter difference between the eyes. The presence of manifest strabismus was recorded whether constant or intermittent; heterophoria was not recorded.

Lens opacities were graded at the time of examination and from photographs. Nuclear opacities were graded using the Wilmer grading system and were classified as "cataract" for nuclear standard 2.0 or greater, of the four standards. The width and height of any posterior subcapsular opacity was measured and defined as ≤1 mm². "Cortical cataract" was defined as opacity ≥4/16 of pupil circumference (23).

All statistical analysis was conducted using SAS® (Version 6.1) statistical software. Chi Square and Fisher's exact tests were used for the categorical data. Test for linear trend in proportion was tested by the Mantel Haenszel chi square test. Multivariate logistic regression was performed to find the independent risk factors associated with defective stereopsis. Presenting visual acuity in the better eye was used in the analyses. A p value of <0.05 was considered to be "statistically significant", in keeping with statistical tradition.

RESULTS

Responses to each test level are shown in Table 2. There was a "statistically significant" difference in the

Table 1. Criteria of passing and failing Lang 1 stereotest.
p=positive response; pp=partial positive response; n=negative response; '=seconds of arc

	Cat 1,200"	Star 600"	Car 550"
Pass	p	p	p
	u	u	u
	p/u	p/u	n
Fail	n	n	n
	p/u	n	n

Table 2. Responses to the Lang 1 stereotest

	Positive response	Uncertain response	Negative response
Cat 1200"	241 (82.5%)	32 (11%)	19 (6.5%)
Star 600"	253 (86.5%)	19 (6.5%)	20 (7%)
Car 550"	250 (85.5%)	22 (7.5%)	20 (7%)

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number of participants who gave a partial positive response to the cat (1200") on the Lang test, compared to either the car (550") or the star (600")(Chi-square, 1 df = 46.2; p<0.001). The proportion of Australian born participants (3.1%) who gave partial positive responses and the proportion of those who were born overseas (3.8%) who gave partial positive responses was similar.

The various combinations of responses are shown in Table 3. Forty-five people (15.4%) gave a partial positive response to one or more shapes. As mentioned in Methods, partial positive responses were regarded as positive responses. With the exception of 2 participants, all those who gave a positive response or gave a partial positive response at level 550" also gave positive responses at the 600" and 1200" levels. Of those who gave a negative response at the 550" & 600" levels only one participant gave a positive response at the 1200" level. There were 2 participants who gave inconsistent responses. One person gave a negative response at the 600" level and gave partial positive responses at the 550" and 1200" levels. The other person gave negative responses at the 1200" and 600" levels, but gave a partial positive response at the 550" level. As these cases could not be consistently classified, they were excluded from the statistical analyses. Whether each combination of responses constituted a pass, a fail, or an inconsistent result is indicated in Table 3 (see footnote to Table 3).

For the purpose of analysis, 19 (6.5%) subjects were considered not to have stereopsis (Table 3). Univariate analysis showed that failure on the Lang Test was associated with strabismus, amblyopia, anisometropia, cataract and reduced distance and near visual acuity (see Table 4). Of the 26 strabismus cases, 23 (88.4%) had intermittent deviations. **Failure was not associated with increasing age** (M-H chi-square, 1 df = 0.89; p=0.16) or gender (M-H chi-square, 1 df = 2.87; p=0.09) nor with being born outside Australia (M-H chi-square, 1 df = 0.15; p=0.70) or with those who did not speak English at home (M-H chi-square, 1 df = 0.14; p=0.71).

Table 3. Response combinations to the Lang 1 stereotest.
p=positive response; pp=partial positive response; n=negative response; '=seconds of arc

Cat 1200″	Star 600″	Car 550″	Frequency (%)
p	p	p*	226 (77.4%)
p	p	u*	6 (2.1%)
p	u	p*	5 (1.7%)
p	u	u*	3 (1%)
p	p	n*	1 (0.3%)
u	u	u*	8 (2.7%)
u	p	p*	17 (0.8%)
u	p	u*	3 (1%)
u	u	p*	2 (0.7%)
n	n	n**	18 (6.2%)
p	n	n**	1 (0.3%)
u	n	u***	1 (0.3%)
n	n	u***	1 (0.3%)

p*= pass; f** = fail; u***= inconsistent

To ensure that partial positive responses were correctly scored and analyzed as positive responses, the analyses were also conducted with these partial responses excluded. With the partial positive responses eliminated, the results were unchanged. A further analysis included those who had a partial positive response with those who failed. The results were also again not changed.

Multivariate analysis showed that anisometropia and strabismus were associated with decreased stereopsis. Best presenting visual acuity less than 6/12 was also associated with an

Table 4. Significant univariate risk factors for stereopsis.

Risk factors	n	Number Failed(%)	Number Passed(%)	P- value
Strabismus				Chi square = 37.2;
Yes	37	11 (29.7%)	26 (70.3%)	p<0.001
No	253	8 (3.2%)	245 (96.8%)	
Amblyopia				*p<0.001
Yes	8	7(87.5%)	1 (12.5%)	
No	282	12 (4.3%)	270 (95.7%)	
Anisometropia				Chi square=19.0;
Yes	23	7 (30.4%)	16 (69.6%)	p<0.001
NO	265	12 (4.5%)	254 (95.5%)	
Cataract				Chi square=6.3;
Yes	47	7 (14.9%)	40 (85%)	p<0.012
No	242	12 (5.0%)	230 (95.9%)	
Distance VA				Chi square=14.7;
≥6/9	261	13 (5.0%)	248 (95.9%)	p<0.001
<6/9-6/12	17	2 (11.8%)	15 (88.2%)	
<6/12	12	4 (33.3%)	8 (66.7%)	
Near VA <N8				*p=0.012
Yes	3	2 (66.7%)	1 (33.3%)	
No	287	17 (5.9%)	271 (94.1%)	

*Fisher's Exact Test

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increased risk of decreased stereopsis (see Table 5).

DISCUSSION

While the shapes depicted in the Lang 1 Stereotest are stylized representations designed to appeal to children, no adult commented that it was a child's test. However, forty-five of 292 *adult* subjects were *unable* to correctly name one or more of the shapes.

It has been noted that the time to appreciate random dot stereotests decreases with repeated exposure (24). It is possible that the rate of partial positive responses may decrease if more time is given to perform the test. However, the cat (1200") was notably more difficult to name than the car or the star. This difficulty was similar for people from all ethnic backgrounds and whether or not they spoke English. This result suggests that the stylized cat is per se relatively difficult to interpret [even] for an adult population rather than it being a difficulty experienced because of a short test time.

In this pilot study, using the Lang 1 Stereotest, the risk factors associated with defective stereopsis were: strabismus, amblyopia, anisometropia, cataract, and reduced distance visual acuity of <6/12 and reduced near visual acuity of <N8. This remained true even when all partial positive responses were eliminated from the analysis. This was also true when the partial positive responses were included with the failed responses. This finding supports Lang's supposition that partial positive responses may be regarded as positive recognition of stereopsis on this test. Only one person had stereopsis at a level worse than 550", therefore it was not possible to analyze the correlation between various levels of stereopsis and levels of visual acuity. We were unable to evaluate the association between stereopsis and near vision in the multivariate models because only three people had near vision less than N8.

Increasing age was not found to be a risk factor. This could be due to the lack of statistical power because of small numbers. However, the Lang 1

Table 5. Multivariate risk factors for reduced stereopsis.

Risk factors	Odds ratio (95% CL)
Distance visual acuity	
$\geq 6/9$	1.00
$< 6/9\text{-}6/12$	2.9 (0.26, 31.5)
$<6/12$	24.5 (4.8, 124.7)
Anisometropia	8.2 (1.8, 37.7)
Strabismus	7.9 (1.9, 33.5)

Stereotest only measures stereoacuity at 3 levels (550", 600" and 1200") and may not be sufficiently sensitive to detect subtle reductions of stereopsis. In this small sample of 292 participants there were no cases of retinal or optic nerve disorders.

CONCLUSION

This pilot study has provided normative values of adult stereopsis using the Lang 1 Stereotest. It is a quick and easy test to administer. No additional glasses are necessary and the results of the multivariate analyses confirm that the method of scoring those who passed and those who failed the test correctly identified people with defects associated with reduced stereopsis. The results suggest that the Lang 1 Stereotest is sufficiently sensitive as a screening test to detect even mild reduction in visual acuity irrespective of the ocular morbidity. These findings suggest that the Lang 1 Stereotest is as appropriate for screening adult populations as it is for children.

Any loss of stereopsis with advancing age would appear to be the result of specific new or aggravated problems impairing vision or visual acuity and not because of any loss of stereoacuity or steropsis due directly to advancing age per se.

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Abstract translated into Spanish, French and German

Jucio sobre la Estereopsia del Adulto Usando el Stereotest de Lang 1: Un Estudio Piloto

RESUMEN: Antecedentes y Propósito: Emitir un juicio del uso del Stereotest de Lang 1 como muestreo de visión en adultos, de la cual poco es conocido o reportado.

Método: El Stereotest de Lang 1 fue efectuado a 292 participantes consecutivos del proyecto de visión afectada (PVA) con un estudio de seguimiento de cinco años, el cual es un estudio de padecimientos del ojo basado en la población de Melbourne, Australia. El 56.9 % eran mujeres. La media de edad fue de 59.4 años, rango de 44 a 90 años. Una respuesta estereoscópica "positive" fue consignada cuando la imagen del objeto fue nombrada correctamente; una respuesta "parcialmente positiva" cuando la profundidad fue apreciada, pero la figura no pudo ser reconocide; y respuesta "negativa" cuando no se apreció efecto estereoscópico. Las respuestas fueron luego categorizadas de tal modo que la prueba fue "pasada" o "fallada". Una calificación de "pase" fue cuando 3/3 respuestas positivas; 3/3 respuestas parciales positivas; y/o respuestas parciales positivas cuando la