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Normative Values for Near and Distance Clinical Tests of Stereoacuity

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ABSTRACT

Purpose: Extensive literature exists on normative stereoacuity values for younger children, but there is less information about normative stereoacuity in older children/adults. Individual stereotests cannot be used interchangeably—knowing the upper limit of normality for each test is important. This report details normative stereoacuity values for 5 near/distance stereotests drawn from a large sample of participants aged 16-40 years, across 3 studies.

Methods: Participants (n=206, mean age 22.18±5.31 years) were administered the following stereotests: TNO, Preschool Randot, Frisby, Distance Randot, and Frisby-Davis 2. Medians and upper limits were calculated for each test.

Results: Upper limits for each stereotest were as follows: TNO (n=127, upper limit=120” arc), Preschool Randot (PSR, n=206, upper limit=70” arc), Frisby (n=206, upper limit=40” arc), Distance Randot (n=127, upper limit=160” arc), and Frisby-Davis 2 (n=109, upper limit=25” arc).

Conclusions: Normative values for each stereotest are identified and discussed with respect to other studies. Potential sources of variation between tests, within testing distances, are also discussed.

Introduction

A variety of assessment methods are used in clinical practice to measure stereopsis, considered the pinnacle of binocular single vision, in adults and children. Although this measure is considered routine in many clinics, variations in stereotest characteristics can result in difficulties with interpreting the results, and importantly, using the stereocuity value to make informed treatment decisions. While extensive literature exists on stereoacuity values for younger children (see Birch and O’Connor\textsuperscript{1} for a review), there is less information about normative stereoacuity in older children and adults, despite stereocuity altering with age,\textsuperscript{2,3} limiting interpretation. Table 1 presents median/mean stereoacuity values and variance for adults and older children, derived from the literature, for a group of near/distance dissociative randot (Nederlandse Organisatie voor Toegepast Natuurwetenschappelijk Onderzoek [TNO], Preschool, and Distance Randot) stereotests, and non-dissociative real depth (free space) Frisby and Frisby-Davis 2 (FD2) stereotests. The mean sample size based on each unique study in Table 1 is 157, but this is mostly driven by one large-sample study\textsuperscript{4}; discounting this study, the mean sample size is just 57. This would seem to indicate that normative data generated from a larger sample of adults and older children, where repeat measurements of stereoacuity can be important for monitoring heterophoria control (eg, intermittent exotropia\textsuperscript{5,6}), would be beneficial.

This article therefore reports normative values and upper limits for 3 near and 2 distance stereotests in a large sample (n=206) of visually normal adults and teenagers drawn from three studies,\textsuperscript{7-9} as an accessible reference for clinicians/researchers. It also discusses the source of variation in normative values between sources.

Methods

Participants

Participants aged 16-40 years (mean age 22.18±5.31 years) were recruited from the University of Liverpool and Glasgow Caledonian University staff and student population, including qualified and undergraduate eyecare professionals (orthoptists, optometrists, and ophthalmic dispensers). Informed consent was obtained prior to participation. The research followed the tenets of the Declaration of Helsinki. Inclusion criteria were unioocular Bailey-Lovie or ETDRS chart visual acuity (VA) of 0.200

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logMAR or better in each eye, interocular acuity difference <0.200 logMAR, and no ophthalmic defect other than refractive error. Participants wore their habitual correction throughout testing.

**Procedures**

All stereotests were administered within a single test session under fluorescent room lighting (2.70 log cd/m²) according to manufacturer instructions (unless otherwise stated). Stereotest viewing time was not restricted. TNO and Preschool Randot testing distance was fixed at 40 cm using a book stand. The TNO edition used was not recorded but is limited to the 12th and 14th editions. For 89 subjects, the Frisby stereotest was administered according to manufacturer instructions, with testing distance only being measured at the point where the observer starts to struggle to get answers correct. For 38 subjects, a tape measure was additionally used throughout to ensure viewing distance remained constant. For 79 subjects, a chin rest restricted head movement and a stand maintained test plate angle at 90° with a constant viewing distance. These methodological variations are due to the different testing protocols used in the 3 studies. One study used just two near stereotests, the Preschool Randot and Frisby, as it was a repeated measures task involving assessment of near visuomotor task performance, and for another study 18 participants did not complete the FD-2 stereotest due to the end of the loan period for that test from Liverpool Royal Hospital. The numbers of participants completing each test in our study (highlighted in gray) are listed in Table 1.

### Analysis

SPSS 20 (IBM, United States) was used for analysis. Participants unable to elicit any stereo image from a test were assigned an arbitrary value of 10,000 arcsec, as gross stereopsis beyond test floor can still be possible. Bootstrapping (a sample distribution estimate method utilizing random sampling with replacement) was used to determine the 95% confidence intervals for median stereoacuity, which in turn were used to calculate the upper limit for each stereotest. Paired Wilcoxon signed rank testing was used to compare VA between eyes. Stereoacuity was Spearman rank correlated to age and VA. The impact of Frisby testing protocol differences was determined by Kruskal-Wallis testing across data sets and post hoc Mann-Whitney U testing. Bonferroni corrections were applied for multiple comparisons. Mann-Whitney U testing was also used to determine whether different TNO editions may have been used between studies, in light of new research since data collection.

### Results

No significant difference in VA was identified between eyes (Z=-1.85, P=0.065). Monocular VAs were subsequently averaged together. Age significantly (weakly)
positively correlated with FD2 stereoacuity only (rho=0.29, P=0.004). Averaged monocular VA was significantly (weakly) positively correlated with both Randot stereotests (PSR rho=0.194, P=0.005; DR rho=0.269, P=0.002), thus a one-line change in VA, results in a 6″ arc change in PSR stereoacuity based on normative PSR value. In Table 1, the normative median stereoacuity, interquartile range, and upper limit for each stereotest based on our studies is highlighted in gray.

**Impact of differences between Frisby stereotesting methods and TNO print editions**

A significant difference in stereoacuity values existed between datasets for the Frisby stereotest (H=7.76, P=0.021) although median values were identical between data sets, with only the distribution of values varying. A larger spread of values existed within the data set gathered using standard clinical testing protocols,⁷ in comparison to the protocol utilizing a chin rest, fixed-plate angle, and continuously maintained testing distance and height⁸ (difference in maximum stereoacuity=255″ arc, Z=-2.67, P=0.008). No significant differences were identified between the two data sets utilizing the TNO test.

**Discussion**

Median stereoacuity values are largely in agreement with previous studies as highlighted in Table 1, but the variance and upper limit of normality differ in many cases from those of previous studies—in particular, for the Distance Randot we found a smaller upper limit of normality of 160″ arc. The Frisby and FD2 normative values, however, are similar to those gained previously¹¹ with a comparable sample size (n=196). This suggests the possibility that these differences within tests between previous studies and our own may originate from the larger sample size used in our study.

Differences were also identified in the distribution of stereoacuity values where different Frisby testing protocols were used. Although this did not have an impact on median stereoacuity values across data sets, more variability in responses occurred between individuals tested using standard clinical testing procedures as opposed to a more rigid protocol where a chin rest was used to minimize head movement. A weak correlation was found between monocular visual acuity and Randot stereotest performance, but the change in stereoacuity associated with a 1 line VA change is minimal (6″ arc) and of limited clinical significance.

**Table 1** emphasizes the lack of interchangeability of stereotests between clinical testing sessions, and the importance of recording stereotest used. All 5 stereotests evaluated in this study are considered to be global measures of stereopsis, as they utilize random element patterns,¹² in contrast to contour stereotests such as the Titmus Fly test, which assess local stereopsis.¹³ The source of these between-test variations, within testing distances, is therefore likely to relate to individual test design characteristics rather than individual ability for disparity discrimination.

Stereocuity tests can utilize dissociative and non-dissociative presentation methods.¹³ Dissociative methods that utilize polarisers, parallax barriers, or anaglyphs to present disparate images to each eye (eg, Preschool Randot or TNO stereotests) reduce sensory fusion primarily through reduction in retinal illumination or induction of chromatic anisometropia.¹⁴ Non-dissociative presentation uses real depth (a physical depth difference between two planes in free space, eg, Frisby stereotest), removing these sources of reduced sensory fusion. This helps to explain some findings from studies identifying lower thresholds in visually normal participants for real depth stereoacuity compared to the other stereotests highlighted here.¹¹,¹⁵ It is also suggested that the coarser spacing of random element patterns in the Frisby stereotest reduces crowding effects, thus improving the threshold in comparison to Randot stereotests.¹⁶ Other factors include differences in target size⁷,¹⁴,¹⁷,¹⁸ or print edition,¹⁰ although in our study we found no significant difference between data sets for the TNO test, indicating the same print edition had been used between studies.

One limitation of this study is that all participants were recruited from the staff and student population at two universities. An age bias exists in our data towards individuals in their twenties (mean age 22.18±5.31 years), but this also was found to occur in Bohr and Read’s study,¹⁹ which had a similar sample size to ours and was recruited from the general populace of Newcastle.

Overall, the current study has presented guidance for the interpretation of clinical measures of stereoacuity in individuals aged 16-40 years, supplemented by our own normative data from a large sample of visually normal individuals within this age group.

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**Declaration of interest**

The authors report no conflicts of interest.
References