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Randot® Preschool Stereoacuity Test: Normative Data and Validity

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Abstract

Introduction—The Randot® Preschool Stereoacuity Test (RPST) is a widely used 3-book test for the assessment of binocular status. Using a prototype, we previously reported high testability in children as young as 3 years, validity data, and some normative data. Here we report extensive normative and validity data for the final version of the test. In addition, we report normative data for a new, fourth book that adds finer disparities.

Methods—The RPST was administered to 4355 normal children ages 3–18 years and 39 adults in multiple settings. In addition, the RPST along with the new 4th book that added 30 arcsec and 20 arcsec disparity levels was administered to 1402 normal children ages 3–18 years and 33 normal adults. Both the 4-book RPST and the Randot circles were administered to 242 patients with amblyogenic conditions ages 3–18 years.

Results—Mean normal stereoacuity improved from 100 arcsec at 3 years of age to 60 arcsec by 5 years and 40 arcsec by 7 years. The lower limit of normal was 400 arcsec at 3 years, 200 arcsec at 4 years, and 60 arcsec at 7 years. Using the new 4-book version, further improvement in mean stereoacuity could be appreciated beyond 7 years of age to 30 arcsec in the 11–18-year-old and adult groups. Among the 242 patients, RPST stereoacuity was strongly associated with Randot circle stereoacuity ($\chi^2=261.0$, $p<0.001$).

Conclusions—Normative data for the RPST show a monotonic improvement of stereoacuity from age 3 years through the teen years. Patient data support the validity of the RPST.

The Randot® Preschool Stereoacuity Test is a widely used 3-book test for the assessment of binocular status. Using a prototype version, we previously reported high testability in children as young as 3 years, validity data, and some normative data¹. However, there are two important

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limitations to the published normative data. First, the sample size was limited to 146 children spanning a 4-year age range, and some age groups had as few as 16 children. Second, since the time of the original study, it was noted that adults could detect an artifact in the 800 arcsec heart-shaped stimulus of the prototype version²; a series of random dots were aligned by chance, creating part of the outline of a heart which could be seen monocularly even when the Polaroid glasses were worn. This led to a redesign of the 800 arcsec level of the Randot[®] Preschool Stereoacuity Test to eliminate the artifact prior to its availability as a commercial product in 1998. Note that only the paper that originally described the test¹ and the paper that identified the artifact² have used the prototype version of the test.

Here we report extensive normative data for the final 3-book version of the test. In addition, we report normative and validity data for a new format of the Randot[®] Preschool Stereoacuity Test that includes a 4th book with finer disparities.

Methods

Participants

Participants included 5740 healthy term children ages 3–18 years and 72 adults ages 19–39 years in clinical research (Retina Foundation of the Southwest, USA), developmental screening of a birth cohort (University of Bristol, UK) and preschool screening (Memorial University, Canada) settings. These sites were chosen as representative of the various applications of preschool stereoacuity testing and to ensure diversity in ethnicity and socioeconomic status. All normal participants had their stereoacuity tested as part of other ongoing research projects. Therefore, the age distribution is non-uniform. For example, a very large cohort of 11- and 12-year old children were tested as part of the ongoing ALSPAC study³. All children had normal acuity in both eyes assessed with HOTV (7%), Lea symbols (2%), Patti Pics (2%), or ETDRS (89%). None of the normal children had strabismus or anisometropia >1.50 D.

In addition to the normative sample, 242 patients with amblyogenic conditions participated (ages 3–18 years). Eligible amblyogenic conditions included accommodative esotropia, acquire nonaccommodative esotropia, infantile esotropia, intermittent esotropia, intermittent exotropia, anisometropia, and unilateral cataracts. These eligibility criteria were broad so that we could include patients whose stereoacuity ranged from normal to absent in order to evaluate concordance with the Randot[®] circles test.

Informed consent was obtained from the participant (if ≥ 18 years of age) or a parent after details of the study were explained. All aspects of the research protocol were in compliance with the Declarations of Helsinki and approved by the University of Texas Southwestern Medical Center and the ethical committees of the University of Bristol and Memorial University sites.

Protocol

Viewing distance for all stereoacuity tests was 40 cm. The 3-book Randot[®] Preschool Stereoacuity Test (Stereo Optical, Inc., Chicago, IL) was administered to 4355 normal children ages 3–18 years and 39 normal adults ages 19–38 years; testing was conducted according to the test manufacturer's instructions. Each book contains 2 sets of 4 random dot shapes (one is blank, the other three contain shapes) which can be named or matched to the easily visible black-and-white shapes on the other side of the book. Book 1 is presented first to test 200 arcsec and 100 arcsec levels of disparity. If the child is able to correctly identify 2 of 3 shapes at both of these disparity levels, Book 2 is presented next to test 60 arcsec and 40 arcsec disparity. If the child is unable to identify 2 of the 3 shapes at 200 arcsec disparity, Book 3 is presented

instead to test 800 arcsec and 400 arcsec disparity. Stereoacuity is defined as the smallest disparity at which the child is able to correctly identify at least 2 of 3 shapes.

In addition, the Randot[®] Preschool Stereoacuity Test along with the new 4th book that added 30 arcsec and 20 arcsec disparity levels was administered to 1402 normal children ages 3–18 years and 33 normal adults ages 19–39 years. Many of these children (N=1255) and adults (N=8) had been tested with the 3-book version on a prior visit 6 months to 5 years earlier. The same testing protocol was used, with Book 4 presented only if the child was able to pass the 40 arcsec level in Book 2. Finally, both the 4-book Randot[®] Preschool Stereoacuity Test and the Randot[®] circles test (Stereo Optical, Inc., Chicago, IL) were administered according to manufacturer's instructions to 242 patients with amblyogenic conditions ages 3–18 years. Patients wore their habitual optical correction during stereoacuity testing.

Statistical Analyses

Stereoacuities were converted from arcsec to logarc sec in order to compute means and standard deviations for each age group. To report the mean stereoacuity as a function of age in tabular form, means were converted back to arc sec and rounded to the next larger disparity level available in the Preschool Randot[®] Stereoacuity Test; we felt that this was more useful as a guide for norms since un-rounded means have little relevance to daily clinical use of a test that has discrete levels. Lower limit for normal performance on the stereoacuity test as a function of age was defined using the tolerance limit, which is calculated as two standard deviations from the mean (defining the cut-off value above which 95% of the normal population would be expected to perform in each age group).

Results

Normative Data

Using the 3-book format, mean normal stereoacuity improved from 100 arcsec at 3 years of age to 60 arcsec by 5 years and 40 arcsec by 7 years. The lower limit of normal was 400 arcsec at 3 years, 200 arcsec at 4 years, and 60 arcsec at 7 years. Details of the mean stereoacuity and lower tolerance limit for normal by age group is provided in Table 1 for the 3-book format of the test.

Table 1 also shows that with the new finer disparity 4-book version, mean stereoacuity improved to 30 arcsec by 7–8 years. Details of the mean stereoacuity and lower tolerance limit for normal by age group is provided in Table 1 for the 4-book format of the test. Although none of the 3-year-old children were able to pass at the 20 arcsec level of stereoacuity, the percentage of children who were able to perform successfully at the finest stereoacuity level improved steadily with age; for example, 15% of the 7–8-year olds and 47% of 11–18-year-olds were able to discriminate 20 arcsec.

In order to verify that the re-design of the 800 arcsec heart-shaped stimulus in no longer provided a monocular cue, 15 adults and 26 children ages 5–18 years were asked to view the 800 arcsec disparity level of the final version of the Randot[®] Preschool Stereoacuity Test monocularly through the polarizing glasses. We repeated the Holmes and Leske² experiment by querying the participants about which of the four locations contained the heart. None of the 41 children or adults reported that they perceived a heart. When forced to make a choice among the four alternatives, 7 of the 41 (17%) identified the correct location, a result that suggests chance performance (25%).

Validity

Stereoacuity results from the 242 patients with accommodative esotropia, other forms of horizontal strabismus, anisometropia, or unilateral cataracts are summarized in Table 2. Overall, Randot® Preschool Stereoacuity Test (4-book test) stereoacuity was strongly associated with Randot® circle stereoacuity ($\chi^2 = 261.0$, $p < 0.001$). Only 3 patients (1.2%) with poor or nil stereoacuity (800 arcsec to nil) on the Randot® Preschool Stereoacuity Test had better stereoacuity on the Randot® circles test.

Discussion

Normative data for the Randot® Preschool Stereoacuity Test show a monotonic improvement of stereoacuity from age 3 years through the teen years. Mean stereoacuity as a function of age using the Randot® Preschool Stereoacuity Test is similar to that reported for the Randot® test.⁴⁻⁷ Patient data comparing results from the Randot® Preschool Stereoacuity Test and the Randot® circles test support the validity of the Randot® Preschool Stereoacuity Test. High test-retest reliability has already been reported for the final version of the Randot® Preschool Stereoacuity Test within a population of pediatric patients with diverse binocular sensory function, with 72% of tests and re-tests in perfect agreement and an additional 24% of tests and re-tests differing by only one disparity level.⁸

Quantitative measurement of stereoacuity is helpful in the management of strabismus and amblyopia and in the assessment of treatment success and safety in pediatric clinical trials. For measurement of stereoacuity, the Randot® Preschool Stereoacuity Test has two distinct advantages over other available stereoacuity tests. First, the success rate is high in the preschool age range, with 89–93% of children age 3 to 5 years able to complete the test¹. The Titmus and Randot® tests have testability rates of only 28%-80% in the same age range¹. Second, since it is a random dot test, the Randot® Preschool Stereoacuity Test contains no monocular cues. Patients with severe binocular vision abnormalities often are able to correctly identify targets with disparities as fine as 200 arcsec in the Randot® and Titmus circles tests^{2, 9, 10}.

The extensive normative data set presented here, including means and lower tolerance limits, should be useful in quantitative assessment of binocular sensory status in clinical management, planning of outcome assessment in clinical trials, and in setting screening referral criteria.

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Table 1

Randot® Preschool Stereoacuity Test norms

Age group (years)	3-book version			4-book version		
	N	Mean (arcsec) ^d	Lower limit (arcsec) ^{a,b}	N	Mean (arcsec) ^d	Lower limit (arcsec) ^{a,b}
3	138	100	400	23	100	400
4	217	100	200	63	100	200
5	104	60	200	23	60	200
6	46	60	100	21	40	100
7-8	44	40	60	26	30	60
9-10	56	40	60	41	30	60
11-18	3750	40	60	1205	30	60
19-38	39	40	40	33	30	40
Total	4394			1435		

^a rounded to the next larger disparity level available in the Randot® Preschool Stereoacuity Test

^b Lower Limit is defined as the tolerance limit, which is calculated as two standard deviations from the mean (defining the cutoff value above which 95% of the normal population would be expected to perform in each age group).

Table 2Comparison of stereoacuity measured using the Randot[®] Preschool Stereoacuity Test and the Randot[®] circles test

	Circles ≤ 70 arcsec	Circles 100–400 arcsec	Circles 800 arcsec- nil	Total
Preschool ≤ 70 arcsec	145	0	0	145
Preschool 100–400 arcsec	10	14	16	40
Preschool 800 arcsec-nil	1	2	54	57
Total	156	16	70	242