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WIDE RANGE ACHIEVEMENT TEST IN AUTISM SPECTRUM DISORDER: TEST-RETEST STABILITY^{1, 2, 3}

PAUL B. JANTZ

Texas State University

ALYSON L. FROELICH

Department of Psychology, University of Utah

ANNAHIR N. CARIELLO

Department of Psychiatry, School of Medicine, University of Utah

JEFFREY ANDERSON

Departments of Radiology and Bioengineering, University of Utah

ANDREW L. ALEXANDER

Department of Medical Physics, Department of Psychiatry, Waisman Laboratory for Brain Imaging and Behavior, University of Wisconsin–Madison

ERIN D. BIGLER

Department of Psychology, Brigham Young University

MOLLY B. D. PRIGGE

Department of Pediatrics, School of Medicine, University of Utah, Waisman Laboratory for Brain Imaging and Behavior, University of Wisconsin–Madison

BRITTANY G. TRAVERS

Occupational Therapy Program, Department of Kinesiology, Waisman Laboratory for Brain Imaging and Behavior, University of Wisconsin–Madison

BRANDON A. ZIELINSKI

Department of Pediatrics and Neurology, School of Medicine, University of Utah

NICHOLAS LANGE

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⁴<http://www.ncbi.nlm.nih.gov/pubmed>

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¹Address correspondence to Paul B. Jantz, Department of Counseling, Leadership, Adult Education, and School Psychology, ED 4033, Texas State University, 601 University Dr., San Marcos, TX 78666 or (pj16@txstate.edu)..

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Departments of Psychiatry and Biostatistics, Harvard University

Neurostatistics Laboratory, McLean Hospital, Belmont, MA

JANET E. LAINHART

Department of Psychiatry, Waisman Laboratory for Brain Imaging and Behavior, University of Wisconsin–Madison

Summary

The principal goal of this descriptive study was to establish the test-retest stability of the Reading, Spelling, and Arithmetic subtest scores of the Wide Range Achievement Test (WRAT–3) across two administrations in individuals with autism spectrum disorder. Participants ($N=31$) were males ages 6–22years ($M=15.2$, $SD=4.0$) who were part of a larger ongoing longitudinal study of brain development in children and adults with autism spectrum disorder ($N=185$). Test-retest stability for all three subtests remained consistent across administration periods ($M=31.8$ mo., $SD=4.1$). Age at time of administration, time between administrations, and test form did not significantly influence test-retest stability. Results indicated that for research involving individuals with autism spectrum disorder with a full scale intelligence quotient above 75, the WRAT–3 Spelling and Arithmetic subtests have acceptable test-retest stability over time and the Reading subtest has moderate test-retest stability over time.

The standard neuropsychological battery for individuals 6 years and older commonly employs some screening measure of academic achievement (Lezak, Howieson, Bigler, & Tranel, 2012). In developmental disorders, academic screening tests like the Wide Range Achievement Test (WRAT; Jastak, 1946; Jastak & Jastak, 1965, 1976, 1978; Jastak & Wilkinson, 1984; Wilkinson, 1993) are commonly used as a basic index of academic proficiency, which is especially important in terms of calibrating demographic comparisons between those with developmental disorder and typically developing controls. Such academic screening methods have been employed in studies on children with autism spectrum disorder (Luiselli, Campbell, Cannon, Dipietro, Ellis, Taras, *et al.*, 2001), low birth-weight (O’Keeffe, O’Callaghan, Williams, Najman, & Bor, 2003), sleep disorders (Bourke, Anderson, Yang, Jackman, Killedar, Nixon, *et al.*, 2011), Huntington’s disease (O’Rourke, Adams, Duff, Byars, Nopoulos, Paulsen, *et al.*, 2011), cognitive impairment (Ahl, Beiser, Seshadri, Auerbach, Wolf, & Au, 2013), epilepsy (Berg, Caplan, Baca, & Vickrey, 2013), heavy prenatal alcohol exposure (Crocker, Riley, & Mattson, 2015), and children who have been abused (Mills, Alati, O’Callaghan, Najman, Williams, Bor, *et al.*, 2011). Also, parental or other informant information about a child’s academic ability is typically estimated by survey instruments, and having an actual ability measure provides external confirmation for parental and informant reports of academic skills (Arciuli, Stevens, Trembath, & Simpson, 2013).

To date, the stability of the WRAT as a measure for academic proficiency has not been established in individuals with autism spectrum disorder. If WRAT scores remain relatively stable over time, a single score at one time point could be used in a longitudinal design. Since the derived standard score is age-adjusted, an unchanged standard score between two time points would argue for stability and use of a single measure at just one time point. This

would be important because in longitudinal designs there is always a potential problem with missing data, availability for testing at certain time points, and issues of time and subject compliance to complete testing.

Discrepancy comparisons between the WRAT Reading, Spelling, and/or Arithmetic and more modifiable, fluidly changing functions (e.g., memory) represent a common approach in neuropsychological research (Lezak, *et al.*, 2012). However, the stability of the WRAT subtests as an anchor of general academic ability in longitudinal studies in those with a neuropsychiatric disorder has not been established. Specifically, this has not been addressed in autism spectrum disorder. Furthermore, if a subtest on the WRAT exhibits adequate stability over time, performance at one time point may be used as an anchor for other time point comparisons.

The WRAT-3 was normed on a stratified sample of 4,433 individuals between the ages of 5 and 75 years. In the United States, school-age children with autism spectrum disorder are considered to be children with a disability and provided with educational services under a special education classification of Autism (Individuals with Disabilities Education Improvement Act of 2004). Although “special education students were included in the sample, as randomization would allow” (Wilkinson, 1993, p. 27), the number of these students and their special education eligibility classification is not made available in the manual. Therefore, it is not known if individuals with autism spectrum disorder were included in the norm sample.

A search of the PubMed biomedical index database⁴ conducted at the time of this article indicated that six of the 344 articles containing “Wide Range Achievement Test” in the title (or as key words) involved research participants with autism spectrum disorder. Of these six articles, none were longitudinal studies. Major efforts are underway to longitudinally examine cognitive and brain development in individuals with autism spectrum disorder (Howlin, Moss, Savage, & Rutter, 2013; Malesa, Foss-Feig, Yoder, Warren, Walden, & Stone, 2013; Travers, Bigler, Tromp, Adluru, Froehlich, Ennis, *et al.*, 2014) as well as the efficacy of a variety of intervention and treatment outcomes (Siller, Hutman, & Sigman, 2013; Wan, Green, Elsabbagh, Johnson, Charman, Plummer, *et al.*, 2013; Troyb, Orinstein, Tyson, Helt, Eigsti, Stevens, *et al.*, 2014). In such research designs, a very practical question arises as to whether a screening academic measure is longitudinally stable, which has not been previously addressed in this population using the WRAT. The current study analyzes data obtained during the initial four years of a longitudinal study of males with autism spectrum disorder that began in the late 1990s (see Bigler, Tate, Neeley, Wolfson, Miller, Rice, *et al.*, 2003). As the fourth edition of the WRAT (WRAT-4; Wilkinson & Robertson, 2006) was not available at the outset of the study, the WRAT-3 was used for the study’s duration in order to maintain data homogeneity. Although the WRAT-4 has been available since 2006, the WRAT-3 continues to be used in research involving children (Berg, *et al.*, 2013; McNally, Bangert, Dietrich, Nuss, Rusin, Wright, *et al.*, 2013; Crocker, *et al.*, 2015) and adults (O’Rourke, *et al.*, 2011; Light, Swerdlow, Rissling, Radant, Sugar, Sprock, *et al.*, 2012). This continued use of the WRAT-3 supports the purpose of the current study.

⁴<http://www.ncbi.nlm.nih.gov/pubmed>

Research goal. To establish the test-retest stability of the WRAT–3 Reading, Spelling, and Arithmetic subtest scores across two administrations, an average of 2.5 yr. apart, in a sample of individuals with autism spectrum disorder.

METHOD

Participants

This study analyzed archival data obtained between 2006 and 2010 (see Prigge, Bigler, Fletcher, Zielinski, Ravichandran, Anderson, *et al.*, 2013; Travers, *et al.*, 2014). For the purpose of this study, the participants were 31 males diagnosed with autism spectrum disorder between the ages 6 and 22 years. ($M = 15.23$, $SD = 3.95$) who were a subset of a larger longitudinal study of brain development in children and adults with autism spectrum disorder ($N = 185$). This age range was selected because it represents individuals who would be eligible for special education services in public schools in the United States—a frequently studied age group. The participants were selected from a variety of community sources as well as research conducted at the University of Utah. All individuals were rigorously diagnosed with autism spectrum disorder using the Autism Diagnostic Interview–Revised (Lord, Rutter, & LeCouteur, 1994), the Autism Diagnostic Observation Schedule–Generic (Lord, Risi, Lambrecht, Cook, Leventhal, DiLavore, *et al.*, 2000), and the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 1994). Medical causes of autism were excluded through history, physical examination, Fragile-X gene testing, and karyotype. Full Scale IQ was measured using the Wechsler Abbreviated Scale of Intelligence (Wechsler, 1999) and ranged from 76–121 ($M = 99.84$; $SD = 13.82$).

Measure

The WRAT–3 was designed to measure basic academic skills in three areas: Reading (recognizing/naming letters, pronouncing words out of context), Spelling (participant writing his name; writing dictated letters/words), and Arithmetic (counting, reading number symbols, solving oral problems, and doing written computations). It is a standardized test that uses a single level format and two equated alternative forms: Blue and Tan (Wilkinson, 1993). The forms can be used singularly or in conjunction with one another (Combined form) for a total of nine tests. The Combined form merges the Blue and Tan Reading tests into a single Reading test, the Blue and Tan Spelling tests into a single Spelling test, and the Blue and Tan Arithmetic tests into a single Arithmetic test.

The reported reliability median test coefficient alphas of the WRAT–3 range from .85 to .95 over the nine tests with the three combined tests ranging from .92 to .95. The reported alternate form median test coefficient alphas are .92 for Reading, .93 for Spelling, and .89 for Arithmetic. The total sample raw score correlations are reported to be .98 for Reading, .98 for Spelling, and .98 for Arithmetic. As part of the WRAT–3 standardization, test-retest reliability coefficients were established for all three subtests. The reported test-retest corrected stability coefficients for 142 children in the norm group between the ages 6 and 16 years ($M = 10.5$, $SD = 4.0$) were based on standard scores and range from .91 to .98 on the nine tests: Reading = .96 (Tan) to .98 (Blue), Spelling = .93 (Blue) to .96 (Tan), and

Arithmetic = .91 (Tan) to .94 (Blue). The average delay between test and retest was 37.4 days ($SD = 7.2$). Discriminate analysis was conducted using 111 children from the norm group and “40 children ... in a gifted program ... 47 children receiving special programming for learning disabilities and 24 children in an educable mentally handicapped program” (Wilkinson, 1993, p. 184) for a total of 222 children. The age range for these four groups was reported to be 8.5 to 12.5 yr. ($M = 10.6$). Correct predications for each group were 85% for children in the gifted group, 72% for children in the special programming for learning disabilities group, 83% for children in the educable mentally handicapped program group, and 56% for children in the control group.

Procedure

The WRAT-3 was administered as part of a comprehensive battery of neuropsychological tests. Equated alternative forms (Blue and Tan) were randomly assigned and tests were administered and scored following standardized protocol outlined in the test administration manual. The range of months between test administrations (Time 1 and Time 2) was 16.6 to 39.7 ($M = 31.8$ mo., $SD = 4.1$).

Analysis

SPSS (IBM Corp., 2012) was used to calculate test-retest reliability coefficients for the WRAT-3 Reading, Spelling, and Arithmetic subtests and to complete an independent-samples t test and a repeated-measures analysis of variance (ANOVA). A reliable change index was calculated to assess whether the magnitude of change for an individual was statistically reliable. Due to the length of time between test administrations, an adjusted reliable change index for practice effect was not calculated.

RESULTS

Test-retest reliability was calculated for each of the WRAT-3 subtests. Pearson product-moment correlations were calculated between the scores at Time 1 and Time 2 for each of the WRAT-3 subtests. The test-retest coefficient was .70 for Reading, .84 for Spelling, and .86 for Arithmetic. Of the 31 participants, 10 were administered the Blue form at Time 1 followed by the Blue form at Time 2 (Group 1); the other 21 were administered the Tan form at Time 1 followed by the Blue form at Time 2 (Group 2). A difference score was computed for each WRAT-3 subtest (Reading, Spelling, and Arithmetic) by subtracting Time 1 test score from Time 2 test score. An independent-samples t test was run for the two groups using the difference scores as the dependent variables. There were no statistically significant differences in Reading, Spelling, or Arithmetic score differences based on the order of the form taken by the participant (Table 1).

A repeated-measures ANOVA was calculated to test for interaction effects between Reading, Spelling, and Arithmetic scores (independent variable) and age (months) at the time of test administration and time (days) between administration (dependent variables). Results indicated no group differences.

The reliable change index cutoff scores for the Reading, Spelling, and Arithmetic subtests were calculated from the test-retest data following procedures outlined by Jacobson and

Truax (1991). The reliable change indices, derived by multiplying the SE_{diff} by 1.64 or 1.96, set the probability level under the normal curve to $p < .10$ or $p < .05$, respectively. That is, reliable change indices set up a prediction interval where 90% (95%) of the participants' scores should fall with only 5% (2.5%) of scores on the upper end and 5% (2.5%) on the lower end falling outside the interval occurring randomly. Therefore, those scores exceeding the 5% (2.5%) would be considered meaningful. Table 2 shows the SEM , SE_{diff} , and reliable change index, and Table 3 displays the number of participants showing test-retest changes on WRAT-3 subtests that exceeded the reliable change index of 90% and 95% confidence interval.

DISCUSSION

The present study examined the test-retest stability of the WRAT-3 (Wilkinson, 1993) Reading, Spelling, and Arithmetic subtests scores in a sample of individuals with autism spectrum disorder with full scale intelligence quotients above 75. The Spelling and Arithmetic subtest scores were found to have high stability (.84 and .86, respectively) among this sample, and the Reading subtest scores were found to have moderate stability (.70). When determining the magnitude of change for an individual, the SEM was lower for the Reading and Spelling subtests than for the Arithmetic subtest. This resulted in the need for larger reliable change criteria for the Arithmetic subtest. Given that the range of reading score change is relatively low in this sample, research is needed to further explore this relationship. Accordingly, these findings represent acceptable test-retest stability for the WRAT-3 Spelling and Arithmetic subtests and moderately acceptable test-retest stability for the Reading subtest. The current findings suggest that in autism spectrum disorder the WRAT-3 Reading subtest may not be the optimal measure for assessing stability over time. However, this may relate to the fact that for a diagnosis of autism spectrum disorder there has to be some deficit in communication (American Psychiatric Association, 2013). Also, reading ability may potentially be more sensitive to the effects of the underlying “communicative” deficits associated with autism spectrum disorder, so this is an area for further research. Davidson and Ellis Weismer (2014) make the case that several potential core aspects of autism relate to reading ability, and therefore the higher variability may be a function of the disorder itself (see also Jacobs & Richdale, 2013). Therefore, while the WRAT-3 Reading subtest in this sample ostensibly had less stability, moderate stability may still be acceptable for a single measure, although further research would be needed to confirm this possibility.

Within the confines of this investigation, the results of this study indicated the stability of the WRAT-3 Spelling and Arithmetic subtests over time, suggesting their potential viability as measures for use in longitudinal studies for individuals with autism spectrum disorder in this age range (6–22 years) and intelligence level (full-scale intelligence quotient = 76–121). Given this level of stability, a potential practical application of these findings is that instead of having to obtain a full WRAT-3 profile at two time points (e.g., 2.5 yr. apart) to establish a reliable childhood (or early adolescent) baseline of academic ability to which an “outcome score” at 21 years of age or later could be compared, only a single WRAT-3 Spelling or Arithmetic score would be needed at baseline. Since the WRAT-3 Reading subtest may be associated with greater variability over time, however, the Reading subtest may not be the

optimal academic measure to use, although it may still be acceptable. If the Reading subtest were used, the potential greater variability that may accompany reliance on the Reading subtest as an anchor would need to be clearly noted.

According to the WRAT-4 Professional Manual (Wilkinson & Robertson, 2006), the “WRAT-3 Reading, Spelling and Arithmetic subtests were judged to need only minor revision for their retention in the WRAT-4” (p. 33). Given that there were only minor changes to the WRAT-3 subtests, indicating strong relatedness between the two versions of the test, it could be speculated that performance on the three individual subtests by participants in this study would not differ significantly if the three WRAT-4 subtests were used; however, further research would be needed to confirm this before generalizations to the WRAT-4 could be made with any confidence.

This study is not without other limitations. There were no female participants. All participants had full-scale intelligence quotients between 76 and 121, and greater variability may be expected in samples with lower IQs. The sample participants ranged in age from 6 to 22 years, and such a wide age range likely contributed to variability in test stability. Furthermore, along these lines there was no control for kind and type of educational experience received by the different participants. Finally, the sample size was small, which limits the generalizability of the results.

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TABLE 1INDEPENDENT SAMPLES *t* TEST RESULTS FOR WRAT-3 READING, SPELLING, AND ARITHMETIC DIFFERENCE SCORES ($N = 31$)

Subtest	Group 1 ($n = 10$)		Group 2 ($n = 21$)		M Difference	<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Reading	0.10	6.90	-3.71	12.66	3.81	0.89	.38
Spelling	1.70	6.08	-0.33	8.14	2.03	0.70	.49
Arithmetic	-0.90	11.03	-2.14	11.56	1.24	0.28	.78

Note.—Group 1: Blue form at Time 1 followed by the Blue form at Time 2. Group 2: Tan form at Time 1 followed by the Blue form at Time 2.

TABLE 2

RELIABLE CHANGE INDEX SCORES BASED ON STANDARD ERRORS OF MEASUREMENT

Subtest	<i>SEM</i>	<i>SE</i> _{diff}	RC Index (90%)	RC Index (95%)
Reading	8.09	11.44	± 18.76	± 22.42
Spelling	8.25	11.66	± 19.12	± 22.85
Arithmetic	12.76	18.05	± 29.60	± 35.38

TABLE 3

NUMBER OF SUBJECTS SHOWING TEST-RETEST CHANGES THAT EXCEED THE RELIABLE CHANGE INDEX OF 90% AND 95% CONFIDENCE INTERVAL ($N = 31$)

Subtest	90%CI			95%CI		
	Gain	No Change	Loss	Gain	No Change	Loss
Reading	1	27	3	0	30	1
Spelling	0	30	1	0	30	1
Arithmetic	0	30	1	0	31	0