Woodcock-Muñoz™

Language Survey–Revised

nu Normative Update

Technical Supplement

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Overview of the WMLS-R NU

The *Woodcock-Muñoz Language Survey–Revised Normative Update* (WMLS-R® NU) (Schrank & Woodcock, 2009) is a recalculation of the normative data for the *Woodcock-Muñoz Language Survey–Revised* (WMLS-R) (Woodcock, Muñoz-Sandoval, Ruef, & Alvarado, 2005). The WMLS-R NU consists of the *WMLS-R NU Scoring and Reporting Program* (Schrank & Woodcock, 2009), which contains the updated norms, and this technical supplement.

The WMLS-R NU norms replace the original WMLS-R norms. The WMLS-R NU provides the most current data for comparison of obtained WMLS-R scores to other individuals in the U.S. population. The original norms were based on the U.S. Census Bureau's 2000 census projections that were issued in 1996 (Day, 1996). The WMLS-R NU norms are based on the U.S. Census Bureau's 2000 final census statistics; these data were made available in 2005 (U.S. Census Bureau, 2005), subsequent to the publication of the WMLS-R.

In addition to the updated census comparison data, bootstrap-based norm development procedures (Efron & Tibshirani, 1993) were utilized to calculate the WMLS-R NU norms. This procedure resulted in more precise interpretation of an individual's performance because it allowed for estimates of uncertainty and potential bias (in the original sample data) to be reflected in the calculation of the WMLS-R NU norms.

This technical supplement is to be used in conjunction with the *Comprehensive Manual* for the WMLS-R (Alvarado, Ruef, & Schrank, 2005). The *Comprehensive Manual* should be consulted for information on tests and clusters, uses of the test, test administration and scoring procedures, and interpretation. The *Comprehensive Manual* also contains important examiner training information and practice exercises. This supplement contains details of the WMLS-R NU standardization sample based on year 2000 final census statistics, a description of the year 2000 population projection-versus-statistics changes and the impact of these changes on WMLS-R subject weights, a description of the differences in test construction procedures between the WMLS-R and the WMLS-R NU, and a description of median score differences between the WMLS-R and WMLS-R NU tests.

WMLS-R NU Standardization Sample Based on Final Census Statistics

The data for the WMLS-R NU norms were collected from a large, nationally representative sample of 8,782 subjects in more than 100 geographically diverse U.S. communities (see Figure 1 on page 2). Data for the WMLS-R tests were collected during the standardization of the *Woodcock-Johnson III* (WJ III) (Woodcock, McGrew, & Mather, 2001). WMLS-R norms were constructed based on the 2000 U.S. census projections (issued in 1996). The census bureau's Population Projections Program issues projections of the United States resident population based on assumptions about future births, deaths, and international migration. Census projections are estimates of the population for future dates and are subsequently replaced by census statistics.

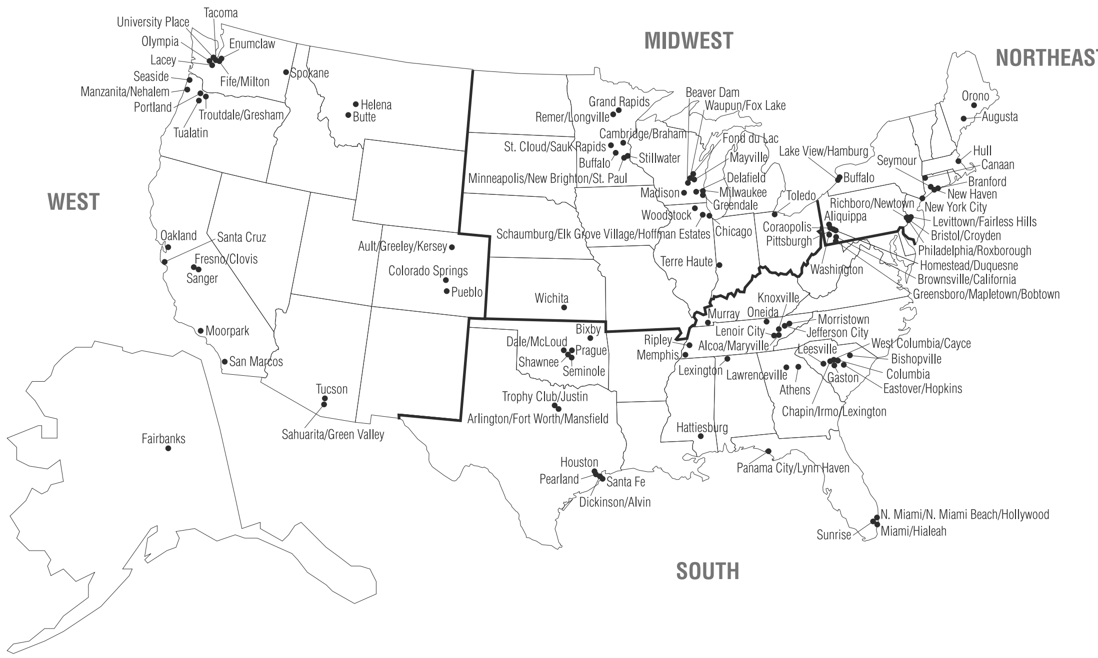

Figure 1.
WMLS-R NU norming sites.

The final 2000 census statistics (U.S. Census Bureau, 2005) produced a somewhat different description of the U.S. population than was assumed from the 1996 projections. For example, according to the bureau's Greg Spencer, "When we took the 2000 census, we found about 6.8 million more people than we were expecting. When we went in and looked at the sources of that growth, we found that during the late 1990s, there was more migration than we had been measuring." (Landphair, 2004, p. 1). Other unanticipated changes in the population were documented, including shifts in age, sex, race, Hispanic origin, and residence. Some states grew at three times the national rate, and people had tended to cluster in locations where jobs were available and climate was preferred.

Table 1 displays the distribution of the WMLS-R NU sample by age and grade. The preschool sample (2 to 5 years of age and not enrolled in kindergarten) was composed of 1,153 subjects. The kindergarten through 12th grade sample was composed of 4,740 subjects. The total adult sample was composed of 2,289 subjects, including 1,727 adults not attending college or university and 1,162 undergraduate and graduate students. The higher density of subjects in the school-age population reflects the need for more concentrated data during the period of time when the abilities measured by the WMLS-R NU undergo the greatest rate of growth.

Table 1.
Distribution of the WMLS-R NU Sample by Age and Grade

Age	Number	Grade	Number
1	8	Kindergarten	306
2	251	1	333
3	314	2	356
4	396	3	490
5	377	4	575
6	308	5	552
7	335	6	368
8	431	7	338
9	533	8	328
10	579	9	285
11	428	10	291
12	352	11	277
13	324	12	241
14	291		
15	302	College	
16	308	13	278
17	248	14	248
18	281	15	206
19	209	16	239
20 to 29	1,013	17+ (graduate students)	191
30 to 39	411		
40 to 49	385		
50 to 59	231		
60 to 69	152		
70 to 79	168		
80+	147		
Total	8,782	**Total**	5,902

The WMLS-R NU sample was selected to be representative, within practical limits, of the U.S. population from ages 24 months to 80 years and older. Subjects were randomly selected within a stratified sampling design that controlled for the following 11 specific community and subject variables:

Census region—Northeast, Midwest, South, West

Community size—Urbanized Area, Urban Cluster, and Rural Area

Sex—male, female

Race—White, Black, American Indian, Asian and Pacific Islander

Hispanic—Hispanic, non-Hispanic

Type of school (elementary, secondary)—public, private, home

Type of college/university—2-year college, 4-year college or university; public, private

Education of adults—less than ninth grade, less than high school diploma, high school diploma, 1 to 3 years of college, bachelor's degree, master's degree or higher

Occupational status of adults—employed, unemployed, not in labor force

Occupation of adults in the labor force—professional/managerial, technical/sales/administrative, service (including Armed Forces and police), farming/forestry/fishing, precision product/craft/repair, operative/fabricator/laborer

Foreign born—native born or foreign born

Tables 2 through 5 contain the sampling variables and their distribution both in the U.S. population according to the 2005 census statistics and in the WMLS-R NU sample. This information is included for the major levels of the total sample (Preschool, Kindergarten through Grade 12, College/University, and Adult). All variables were not relevant at all levels. For example, occupational information was applied only to the adult sample and type of college or university was applied only to the college/university sample. Subsets of the norming sample representing populations with low percentages of occurrence in the United States, such as those classified as American Indian, were systematically oversampled to ensure more accurate contributions to the overall norms.

Table 2.
Distribution of Sampling Variables in the U.S. Population and in the WMLS-R NU Sample—Preschool

Sampling Variable	Percent in U.S. Population	Number Obtained	Percent of Sample	Subject Weight
Census Region				
Northeast	16.9	246	21.3	0.791
Midwest	21.5	179	15.5	1.387
South	37.2	538	46.7	0.797
West	24.4	190	16.5	1.481
Community Size				
Urbanized Area	68.3	771	66.9	1.022
Urban Cluster	10.7	261	22.6	0.471
Rural Area	21.0	121	10.5	2.000
Sex				
Male	51.1	573	49.7	1.029
Female	48.9	580	50.3	0.971
Race				
White	79.0	840	72.9	1.083
Black	15.6	256	22.2	0.701
American Indian	1.0	9	0.8	1.335
Asian and Pacific Islander	4.4	47	4.1	1.083
Not Available	—	1	—	—
Hispanic				
Yes	21.8	136	11.8	1.846
No	78.2	1,017	88.2	0.887
Father's Education				
< High School	20.9	142	12.9	1.617
High School	31.9	298	27.1	1.178
> High School	47.2	659	60.0	0.786
Not Available	—	54	—	—
Mother's Education				
< High School	16.2	124	11.3	1.440
High School	27.4	251	22.8	1.200
> High School	56.3	724	65.9	0.855
Not Available	—	54	—	—
Foreign Born				
Native	98.3	1,110	97.5	1.008
Foreign	1.7	28	2.5	0.681
Not Available	—	15	—	—

Table 3.
Distribution of Sampling Variables in the U.S. Population and in the WMLS-R NU Sample—Grades K through 12

Sampling Variable	Percent in U.S. Population	Number Obtained	Percent of Sample	Subject Weight
Census Region				
Northeast	17.8	1,137	24.0	0.740
Midwest	22.3	982	20.7	1.079
South	35.9	1,492	31.5	1.140
West	24.0	1,129	23.8	1.009
Community Size				
Urbanized Area	68.3	2,813	59.3	1.152
Urban Cluster	10.7	1,027	21.7	0.493
Rural Area	21.0	900	19.0	1.105
Sex				
Male	51.2	2,401	50.7	1.011
Female	48.8	2,339	49.3	0.988
Race				
White	78.5	3,711	78.4	1.002
Black	16.1	687	14.5	1.108
American Indian	1.3	96	2.0	0.631
Asian and Pacific Islander	4.1	242	5.1	0.808
Not Available	—	4	—	—
Hispanic				
Yes	18.7	570	12.0	1.552
No	81.3	4,170	88.0	0.925
Father's Education				
< High School	13.3	528	11.7	1.136
High School	31.8	1,514	33.5	0.948
> High School	54.9	2,474	54.8	1.003
Not Available	—	224	—	—
Mother's Education				
< High School	10.9	433	9.6	1.138
High School	29.5	1,489	33.0	0.894
> High School	59.6	2,595	57.4	1.038
Not Available	—	223	—	—
Type of School				
Public	86.5	4,100	86.7	0.998
Private	11.3	573	12.1	0.930
Home	2.2	54	1.1	1.926
Not Available	—	13	—	—
Foreign Born				
Native	94.3	4,486	95.0	0.992
Foreign	5.7	234	5.0	1.155
Not Available	—	20	—	—

Table 4.
Distribution of Sampling Variables in the U.S. Population and in the WMLS-R NU Sample—College/University

Sampling Variable	Percent in U.S. Population	Number Obtained	Percent of Sample	Subject Weight
Census Region				
Northeast	17.4	189	16.3	1.069
Midwest	22.8	216	18.6	1.229
South	36.3	504	43.4	0.838
West	23.4	253	21.8	1.076
Sex				
Male	51.5	461	39.7	1.298
Female	48.5	701	60.3	0.804
Race				
White	76.1	963	82.9	0.918
Black	13.2	138	11.9	1.111
American Indian	1.3	13	1.1	1.162
Asian and Pacific Islander	9.4	48	4.1	2.276
Hispanic				
Yes	9.7	95	8.2	1.186
No	90.3	1,067	91.8	0.983
Type of School				
Public	76.7	831	71.7	1.069
Private	23.3	328	28.3	0.825
Not Available	—	3	—	—
College				
2-Year	37.9	186	16.0	2.366
4-Year	62.1	976	84.0	0.740
Foreign Born				
Native	85.8	1,051	90.4	0.949
Foreign	14.2	111	9.6	1.484

Table 5.
Distribution of Sampling Variables in the U.S. Population and in the WMLS-R NU Sample—Adults

Sampling Variable	Percent in U.S. Population	Number Obtained	Percent of Sample	Subject Weight
Census Region				
Northeast	18.9	427	24.7	0.766
Midwest	22.5	374	21.7	1.038
South	36.0	544	31.5	1.144
West	22.6	382	22.1	1.020
Community Size				
Urbanized Area	68.4	1,095	63.4	1.078
Urban Cluster	10.7	354	20.5	0.524
Rural Area	20.9	278	16.1	1.297
Sex				
Male	48.5	718	41.6	1.166
Female	51.5	1,009	58.4	0.882
Race				
White	82.6	1,473	85.3	0.968
Black	12.0	185	10.7	1.120
American Indian	0.9	23	1.3	0.675
Asian and Pacific Islander	4.5	46	2.7	1.694
Hispanic				
Yes	12.5	158	9.1	1.368
No	87.5	1,569	90.9	0.963
Education				
< 9th Grade	5.8	108	6.3	0.920
< High School	10.0	223	13.1	0.760
High School	31.7	470	27.6	1.150
1 to 3 Years of College	27.3	376	22.1	1.234
Bachelor's Degree	16.8	269	15.8	1.061
Master's Degree or Higher	8.4	256	15.0	0.561
Not Available	—	25	—	—
Occupational Status				
Employed	62.7	973	56.6	1.108
Unemployed	3.4	167	9.7	0.349
Not in Labor Force	33.9	580	33.7	1.006
Not Available	—	7	—	—
Occupation				
Professional/Managerial	33.8	433	29.8	1.135
Technical/Sales/Administrative	25.3	421	29.0	0.875
Service	16.3	268	18.4	0.883
Farming/Forestry/Fishing	1.6	51	3.5	0.470
Precision Product/Craft/Repair	10.2	129	8.9	1.145
Operative/Fabricator/Laborer	12.8	152	10.5	1.221
Not Available	—	273	—	—
Foreign Born				
Native	85.8	1,583	91.7	0.935
Foreign	14.2	143	8.3	1.719
Not Available	—	1	—	—

2000 U.S. Population Projection-Versus-Statistics Changes: Impact on the WMLS-R NU Subject Weights

Table 6 on page 10 summarizes the U.S. census projection/statistic changes for the school-age (grades K through 12) portion of the WMLS-R norm sample. A review of Table 6 reveals noticeable differences in the U.S. school-age (grades K through 12) population in the sampling domains of Community Size, Hispanic, Father's Education, and Mother's Education. For illustrative purposes, detailed descriptive summary statistics are only presented here for the school-age portion of the WMLS-R NU norm sample. However, some important trends are noted from the data for other age groups.

As seen in Table 6, U.S. Community Size category changes (due to changes in how the U.S. census reported the categories) of more than 2% were noticed in all three categories which, in turn, resulted in noticeable changes[1] in the community size subject weights applied to school-aged subjects classified as living in urban clusters (0.493/1.020 = .48 proportional weight change) and rural settings (1.105/0.873 = 1.27 proportional weight change). Given the change in the U.S. census system, significant changes in community size subject weights (greater than or equal to 20% proportional weight changes) were also noted in the urban cluster and rural category weights in the preschool and adult norm samples.

The percent of the U.S. school-age population classified as Hispanic increased 3.8% from the year 2000 census projections to the year 2000 census final statistics, an increase resulting in a proportional weight change of 1.24 for all school-age Hispanic subjects in the calculation of the NU norms (see Table 6). In other words, Hispanic subjects' scores counted 24% more in the calculation of the school-age NU norms when compared to their contribution to the original WMLS-R norms. A notable increase in the U.S. population classified as Hispanic in the final census statistics also occurred in all other groups: +5.4% (preschool), +1.5% (college/university) and +2.5% (adult), resulting in increased weighting for Hispanic subjects in all groups in the WMLS-R NU norms.

Also of note was a slight percentage increase in school-age subjects who were classified as home-schooled (increased from 1.5% to 2.2%). Although the percentage increase was small, the proportion of school-aged subjects increased (1.44%). Consequently, home-schooled subjects received a higher weighting in the WMLS-R NU norms.

Although the U.S. school-age population census projections and statistics changed significantly in the Father's Education and Mother's Education categories (see Table 6), these significant population changes did not result in significantly different proportional weight changes.[2]

To increase the precision of the WMLS-R NU norm data for all norm group bases (i.e., preschool, school-age, university, and adult), the Foreign Born status of all subjects was included for the first time, resulting in the introduction of a new weighting statistic in the calculation of each subject's final norm weight.

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[1] Significant changes in subject weights are operationally defined as a proportional change in the weight of a magnitude of 20% or more (see Table 6). Thus, weight changes greater than or equal to 1.20 or less than or equal to .80 are highlighted in the final column of Table 6.

[2] Changes in subject weights are a function of changes in the U.S. census projections and statistics and the composition of other norm data. Thus, significant percentage changes in U.S. census figures did not always translate to similar changes in subject weights. Conversely, relatively small changes in the U.S. census projections/statistics could produce larger subject weight changes due to the composition of other norm data.

Table 6.
Changes in Year 2000 U.S. Census Projections (WMLS-R) and Statistics (WMLS-R NU)—Grades K through 12

	WMLS-R	WMLS-R NU		WMLS-R	WMLS-R NU	
Sampling Variable	**Percent in U.S. Population**	**Percent in U.S. Population**	**Percentage Difference[a]**	**Subject Subweight**	**Subject Subweight**	**Proportion Subweight Change[b]**
Census Region						
Northeast	19.0	17.8		0.797	0.740	
Midwest	23.1	22.3		1.062	1.079	
South	35.5	35.9		1.152	1.140	
West	22.4	24.0		0.948	1.009	
Community Size[c]						
Urbanized Area	60.6	68.3	+7.7	1.044	1.152	
Urban Cluster	19.3	10.7	–8.6	1.020	0.493	0.48
Rural Area	20.1	21.0		0.873	1.105	1.27
Sex						
Male	51.2	51.2		1.007	1.011	
Female	48.8	48.8		0.992	0.988	
Race						
White	78.6	78.5		1.000	1.002	
Black	15.7	16.1		1.091	1.108	
American Indian	1.2	1.3		0.599	0.631	
Asian and Pacific Islander	4.5	4.1		0.896	0.808	
Not Available						
Hispanic						
Yes	14.9	18.7	+3.8	1.250	1.552	1.24
No	85.1	81.3	–3.8	0.966	0.925	
Father's Education						
< High School	14.0	13.3		1.198	1.136	
High School	60.1	31.8	–28.3	1.004	0.948	
> High School	25.9	54.9	+29.0	0.909	1.003	
Not Available	—	—		—	—	
Mother's Education						
< High School	12.2	10.9		1.272	1.138	
High School	61.7	29.5	–32.2	0.960	0.894	
> High School	26.1	59.6	+33.5	0.999	1.038	
Not Available	—			—	—	
Type of School						
Public	87.4	86.5		1.006	0.998	
Private	11.1	11.3		0.920	0.930	
Home	1.5	2.2		1.339	1.926	1.44
Not Available	—	—		—	—	
Foreign Born[d]						
Native		94.3			0.992	
Foreign		5.7			1.155	
Not Available		—				

[a] Only WMLS-R percentage differences of +2% or more are reported.
[b] Only WMLS-R subject proportional weight differences of 20% or more are reported (see text).
[c] At the time the WMLS-R was standardized, the U.S. census used the categories of Central City and Urban Fringe, Larger Community and Associated Rural Area, and Smaller Community and Associated Rural Area. For the WMLS-R NU, the old categories were converted to the new U.S. census categories used in this table.
[d] Foreign Born was a new demographic added to the WMLS-R NU sample demographics. It was not used in the WMLS-R.

As reported in the WMLS-R *Comprehensive Manual*, each subject's weight (for each of the respective norm group bases) is the product of his or her individual subweights for each of the norm sampling variables. As seen in Table 6, each school-age subject's contribution to the norm data is a product of each subject's individual subweights for 9 different sampling variables (Census Region, Community Size, Sex, Race, Hispanic, Father's Education, Mother's Education, Type of School, and Foreign Born). The multiplication of 9 different subweight values will produce, for many subjects, a noticeably different single subject weight, even if each of the subweights only changes slightly.

To assess the magnitude of the changes between the projected and final school-age subject statistical weights (as summarized in Table 6), a correlation was calculated between each WMLS-R school-age subject weight and its recalculated WMLS-R NU school-age subject weight. The obtained correlation was .63. If there were no major differences between the year 2000 U.S. population projections and statistics, one would expect very high correlations (with a correlation of +1.0 indicating no major population change at all).

Correlations were calculated for the three other NU norm bases groups (preschool, college/university, adult); the WMLS-R NU subject weight correlations for these three norm bases were .58, .46, and .43, respectively. The correlations for all three groups are lower than the correlation for the school-age group. This suggests that even greater changes in demographics occurred at the preschool, university, and adult levels than in the school-age subgroup.

The moderate to moderately high WMLS-R NU subject weight correlations across all four norm subgroups (.43 to .63) suggest that significant population changes have occurred between the year 2000 census projections (used in the WMLS-R) and the year 2000 census final statistics (used in the WMLS-R NU) and that these changes should result in a reweighting of all subjects to match the final census statistics.

Differences in Norms Construction: WMLS-R Versus WMLS-R NU

The development of test norms requires the establishment of the normative (average) score for each measure for subjects at each specific age (age norms) or grade (grade and university norms) where normative interpretations are intended. In the WMLS-R NU, this normative score is called the reference *W* score (REF *W*). When plotted as a function of chronological age (or grade), the REF *W* scores assume the characteristic of developmental growth curves. These test and cluster REF *W* curves are visual-graphic representations of the average performance of subjects at every age (or grade) for the effective use of the specific measure. The REF *W* curves serve as the foundation for the age/grade equivalent, relative performance index (RPI), and instructional range interpretation features in the WMLS-R NU. In addition, when the standard deviations (*SD*) of the scores at each age are plotted as a function of age/grade, the resultant curves represent the *SD* values that, when combined with the REF *W* values, provide the foundation for the calculation of all standard scores and percentile ranks.

This section describes the differences in the ways the WMLS-R and WMLS-R NU norms were constructed. The Letter-Word Identification test is used as an example throughout the section.

Construction of the WMLS-R Norms

In the WMLS-R, REF *W* values for a given measure are obtained from smoothed curves that pass through sample-based data points that each represent the average REF *W* values of successively ordered (by age or grade) groups or blocks of 50 norm-sample subjects. The WMLS-R Letter-Word Identification test example shown in Figures 2 and 3 helps explain this process. These figures show how the traditional (nonbootstrap) process was used in the calculation of the WMLS-R Letter-Word Identification age-based norms.

To address the realities of sampling procedures that are less than 100% perfect, test developers traditionally statistically weight each subject's scores to represent the cumulative effect of the subject's overrepresentation or underrepresentation (relative to the population) within the norm sample, along several demographic characteristics. The WMLS-R subject norm weights for the demographic variables are reported in Tables 6-2 through 6-5 of the WMLS-R *Comprehensive Manual* (Alvarado, Ruef, & Schrank, 2005). The census-weighted average (median) chronological age and REF *W* scores were calculated for each successive block of 50 age (or grade) subjects. The pairs of age/*W* score values for all blocks served as the raw material for plotting and calculating the WMLS-R norm REF *W* curve for Letter-Word Identification (see Figure 2).[3]

As Figure 2 shows, although the sample values demonstrate a consistent developmental trend, there is "noise" or "bounce" in the trend due to the aforementioned sampling error. To remove the error from the sample-based data, special polynomial curve-fitting, software-based procedures are employed to produce a "smoothed" solution that best approximates the population REF *W* parameter values (McGrew & Wrightson, 1997; Woodcock, 1994). This process is also repeated for the sample-based standard deviations.[4] Figure 3 presents the result of the polynomial curve-fitting procedures when applied to the Letter-Word Identification data points presented in Figure 2. The smoothed curve provides the normative REF *W* values used in the derivation of WMLS-R scores (e.g., age/grade equivalents, RPIs, SSs, PRs).[5]

Construction of the WMLS-R NU Norms

As described above, at the time the WMLS-R was developed and published, the WMLS-R norms were based on established, state-of-the-art statistical population estimation procedures for calculating derived scores (Daniel, 2007; Gorsuch, & Zachary, 1985; Woodcock, 1994). However, these traditional procedures still did not allow for the recognition of the degree of uncertainty that underlies the raw data points used in the norm curve-fitting procedures. For the calculation of the WMLS-R NU norms, it was determined that the certainty of the raw data points used to generate norm curves could be estimated. This in turn would allow for the incorporation of parameter estimate certainty into the selection of the optimal norm curve solution for all measures via the use of a statistical technique known as the bootstrap sampling procedure.

The bootstrap sampling procedure (Efron & Tibshirani, 1993) is a method for assigning measures of accuracy to statistical estimates. According to the *APA Dictionary of Psychology* (VandenBos, 2007), bootstrap is "a computational method for estimating the precision of an estimate of a (statistic) parameter. A random sample of *n* observations is taken, and from this a number of other samples of equal size are obtained by sampling with replacement" (p. 129). Bootstrap sampling procedures can be used to estimate the uncertainty of a statistic via the provision of a bootstrap standard error (confidence band). This feature is useful in estimating the variability and possible bias in sample statistics—in this case, the sample data used for constructing test norms.

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[3] For illustrative purposes, age/REF *W* block data points are presented only for subjects ages 20 to 120 months in Figure 2. In practice, the age/REF *W* curves are plotted across the complete age range of the norms for a test.

[4] Additional sources that provide detailed explanations of norm construction via curve-fitting procedures can be found in Daniel (2007), Gorsuch and Zachary (1985), McGrew and Woodcock (2001), McGrew and Wrightson (1997), and Woodcock (1994).

[5] The smoothed norm curve in Figure 2 is illustrative and is not necessarily the final WMLS-R age norm curve used for the Letter-Word Identification test.

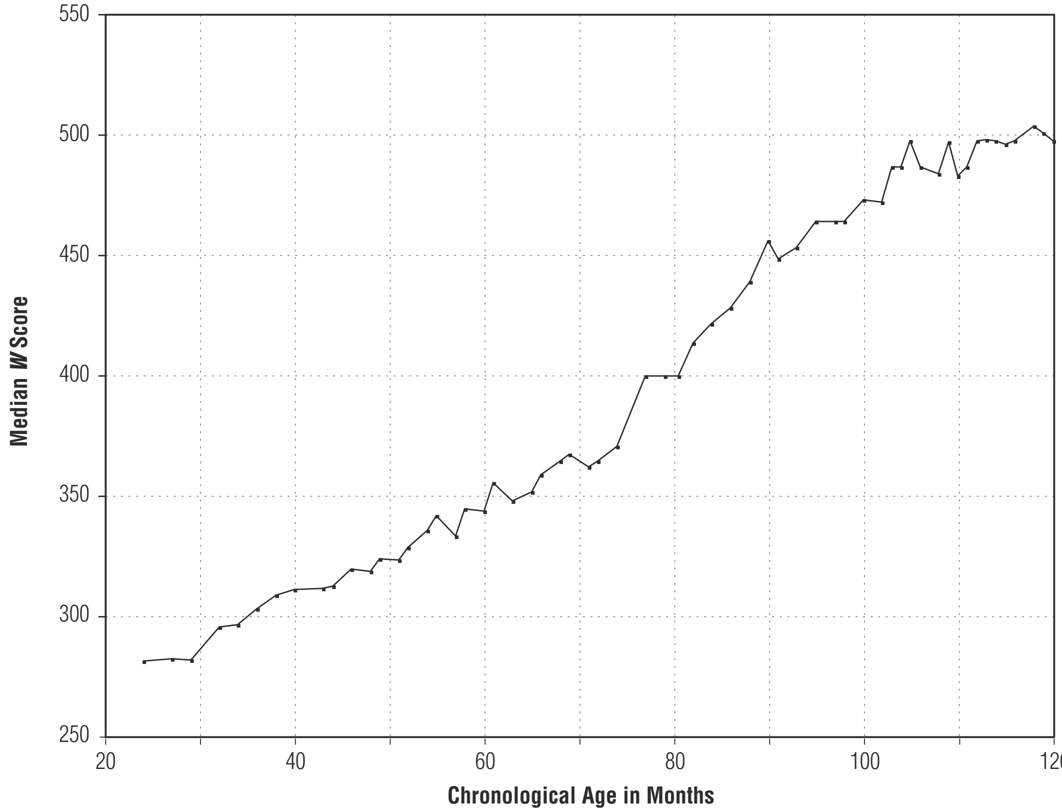

Figure 2.
*Plot of select (ages 20 to 120 months only) WMLS-R Letter-Word Identification age/*W *score sorted block values.*

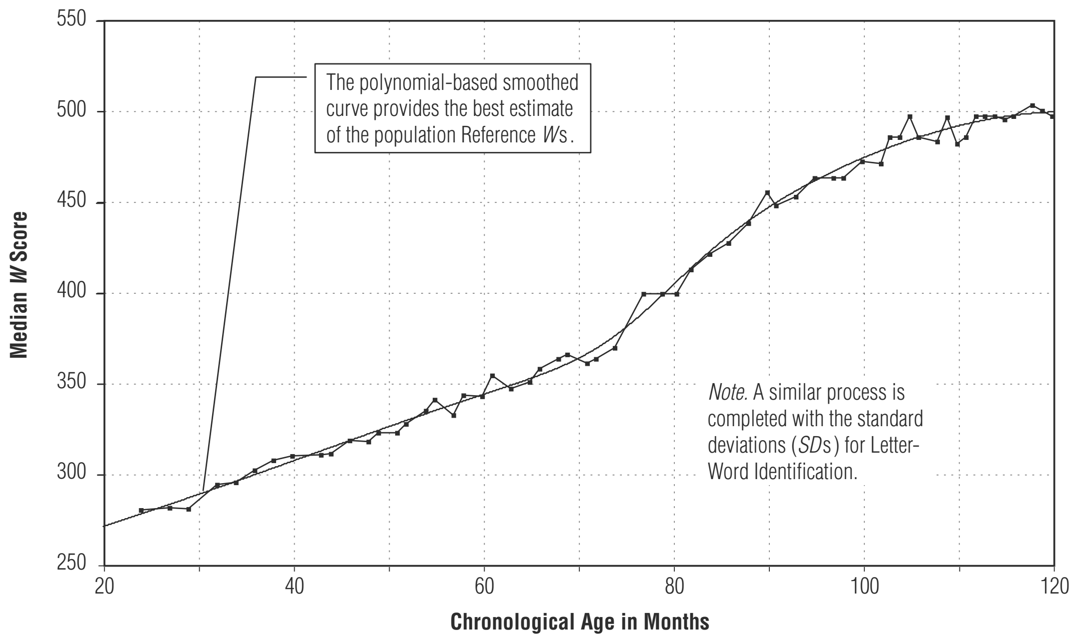

Figure 3.
*Smoothed polynomial curve solution for raw age/*W *score Letter-Word Identification sample-based data presented in Figure 2.*

The bootstrap method works by constructing an empirical distribution of a statistic calculated for a sample of subjects drawn from a population. The variability of the statistic within this distribution can be interpreted as a range in which the true value of the statistic would fall if the entire population were to be measured. In simple terms, the bootstrap process, when applied to the calculation of the age/*W* score data points used for curve fitting, produces a confidence interval/band around the plotted data points, much like the standard error or confidence band clinicians use to bound individual test scores. Repeatedly taking resamples from the obtained norming sample and recalculating the desired statistic constructs the empirical distribution of the statistic or statistics for each resample. As described previously in the WMLS-R example, one of the desired statistics is the collection of REF *W* values for each successively ordered group of 50 subjects.

In the case of the WMLS-R NU norm calculation procedures, 250 resamples of the norming sample subjects were taken.[6] A resample is a sample, with replacement, of the same size as the norming sample. Imagine that, for Letter-Word Identification, each subject's age and *W* score are printed on a Ping-Pong® ball (see Figure 4). All 8,648 balls are placed into a Ping-Pong ball selecting machine (the cylinder in Figure 4). One of the balls (subjects) is randomly selected, the chronological age and *W* score for this selected subject are recorded, and the ball is then thrown back into the machine (replacement) before another ball is selected. This process is repeated 8,648 times and ends up producing one resample. Similar to the process described previously for the WMLS-R Letter-Word Identification norm calculation procedures, Steps 1 and 2 are completed, which results in median chronological ages and *W* scores for each of the age-sorted blocks of 50 subjects. This process (select 8,648 balls, sort records, divide into groups, calculate statistics) is then repeated 250 times. Figure 4 summarizes these steps.

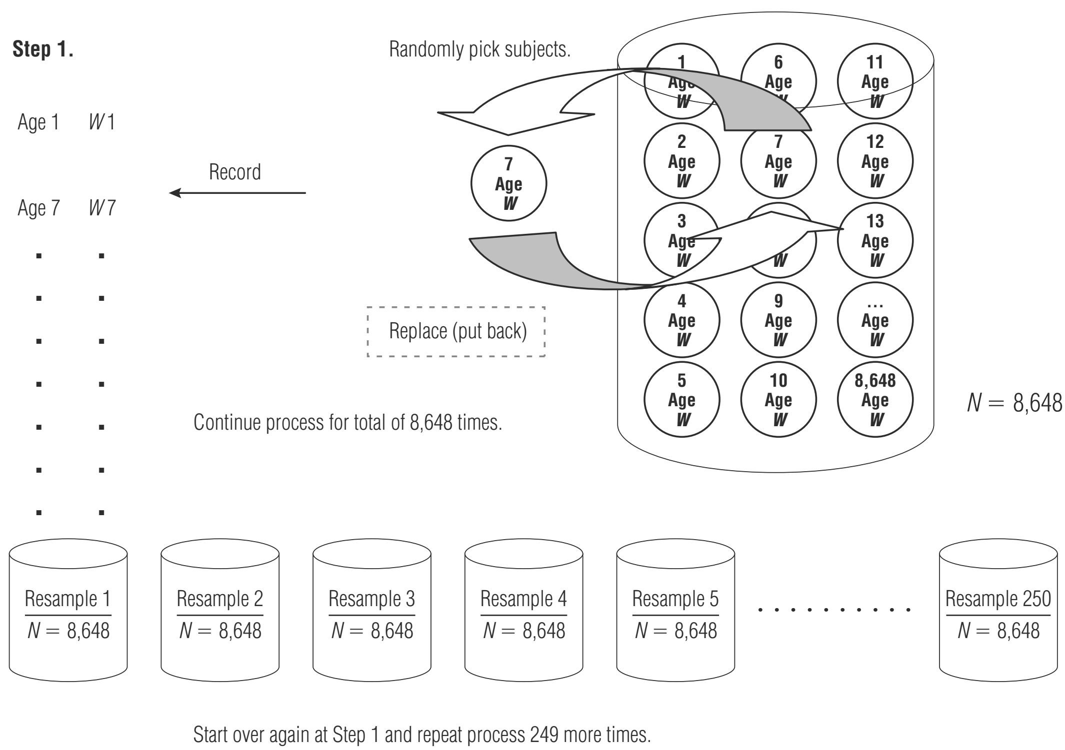

Figure 4. *Creation of 250 WMLS-R NU Letter-Word Identification resamples via random selection of subjects with replacement (bootstrap method).*

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[6] According to Efron and Tibshirani (1993), 50 bootstrap resamples are often sufficient to provide accurate estimates of the standard error of the statistic. With each increase in the number of bootstrap resamples, the amount of improvement in the statistical estimates becomes less. A total of 250 resamples were selected to ensure a high degree of confidence in the estimates of the standard error of the block-level statistics.

At the stage represented by Figure 5, 250 paired values (median chronological age and median *W* score) exist that were calculated for the first (youngest) group in each resample, 250 paired values for the next-youngest group, and so on, up to the 250 paired values for the oldest group of 50 subjects. This process produces an empirical distribution of 250 values of the statistics for the youngest group of subjects across resamples, for the next youngest group, and so on up to the oldest group. From each of those empirical distributions, the 25th and 75th percentile of each statistic is calculated. The range of sample statistics between the 25th and 75th percentile represents the middle 50% of the generated sample statistics. This window or band provides an empirical estimate of the degree of certainty in the sample statistics that will be used for norm curve generation. If a line is drawn from the point defined by the 25th percentile of the chronological age and the 25th percentile of the median *W* score to the point defined by the 75th percentile of each respective statistic, the result, for each of the age-sorted blocks of subjects, is a “stick” or “window” through which smoothed norm curves are fit. That is, instead of fitting norm curves to single data points (see Figure 3), norm curves are now fit to confidence band windows.

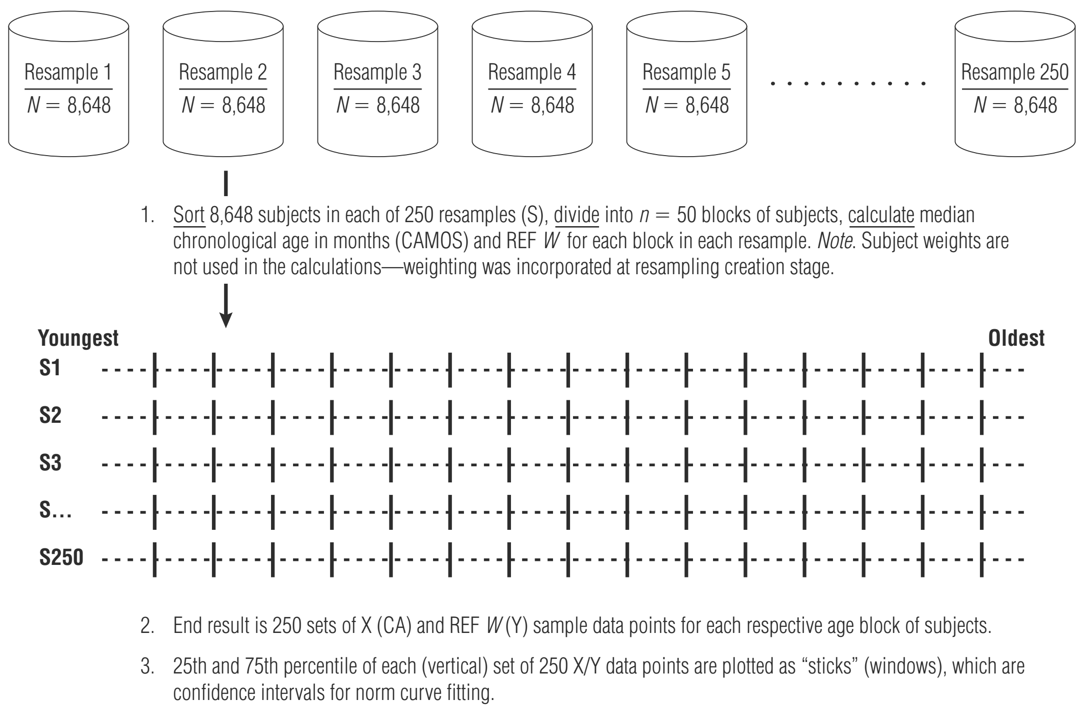
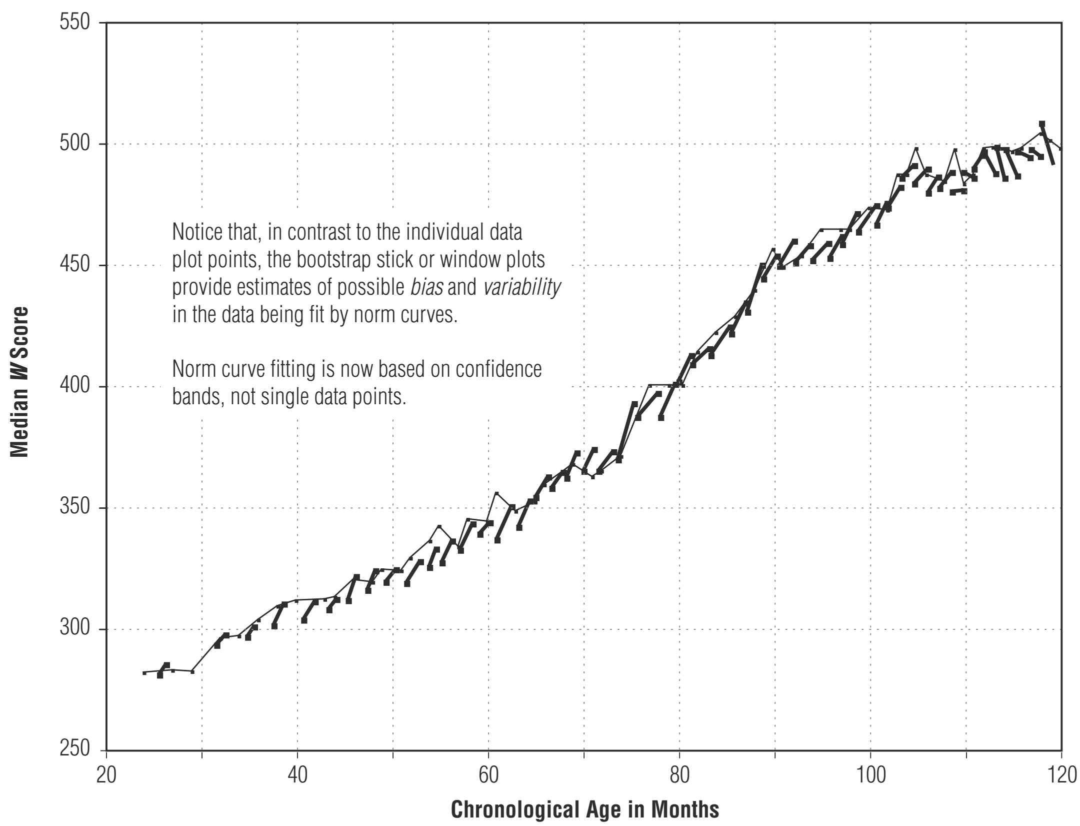


Figure 5.
Calculation of bootstrap-generated sample statistic (see Figure 4) confidence band windows (25th to 75th percentile).

Aside from the generation of bootstrap resamples, the WMLS-R and WMLS-R NU norm development procedures differ in the use of the subject weights. In the case of the WMLS-R NU resampling procedure, it is not necessary that each subject be as likely to be selected as every other subject. This is where the subject weights come into play. In the WMLS-R NU, subject weights are converted to selection probabilities, such that subjects with higher weights have a higher chance for selection and inclusion in any given resample. In fact, some subjects are selected many more times than others as this reflects the notion that the subject weights are necessary to balance out the demographic characteristics in the norming sample with respect to the reference population.

There are distinct advantages to using a resampling plan as described here. First, within each resample, the calculation of statistics for each block or group of 50 subjects is simplified because subject weights are no longer part of the calculation. Instead, the subject weights are incorporated in the probability of including a particular subject in each resample. This makes the calculation of more complex statistics (beyond the median *W* score) possible.

Second, and more importantly, the norm curve-fitting process involves choosing a path through a series of confidence bands (sticks/windows) instead of a series of single data points. At any given age, there is a range of values (with a known degree of certainty) that might be acceptable smoothed norm REF *W* values. When norm curves are fit to a series of individual data points (WMLS-R method), there is a tendency to focus on curve solutions that miss as few data points as possible. By fitting a curve through confidence band windows, the uncertainty inherent in the sampling process (as in any sampling process) is acknowledged and visibly observable, which reduces the tendency for norm curves to "chase individual data points," a process that may result in less precise norm curves. This advantage can be seen in Figure 6 where the WMLS-R NU Letter-Word Identification bootstrap confidence bands are superimposed over the WMLS-R Letter-Word Identification single data points (from Figure 2).



Note. Top and bottom of sticks are slightly offset to allow plotting on the same graph.

Figure 6.
Comparison of WMLS-R Letter-Word Identification REF W *raw data points and WMLS-R NU bootstrap sticks/windows.*

The most obvious difference between the single-point WMLS-R data and the confidence band window-based WMLS-R NU data in Figure 6 is visible between approximately 35 to 65 months of age. The WMLS-R NU confidence bands, which are consistently lower than most of the connected single WMLS-R-derived data, suggest that the WMLS-R single-point values in this age range are biased upward, and, when a norm curve tracks these upwardly biased data points, it will provide less precise norm curve REF *W* estimates. The evidence is clear from the WMLS-R NU confidence-band windows that the population REF *W* values in this age range are likely to track lower than the WMLS-R single-point values. This difference can be seen vividly in Figure 7, where the previously presented WMLS-R curve solution, although appearing to be an optimal solution in Figure 3 (as also suggested by the various polynomial curve-fitting statistics associated with the solution in Figure 3), does "run high" between 35 to 65 months of age. One can have more confidence, given the quantification of the variability in the range of sample estimates for these specific age blocks (as represented by the sticks/windows), that the more precise norm curve should track lower at these ages. A review of both the illustrative WMLS-R and WMLS-R NU curves in Figure 7 demonstrates that the bootstrap method, an improved methodology for norm curve generation (given that it incorporates the uncertainty in the values to be fit in the creation of the norm curves), provides, at a number of age levels, norm curves that either track higher or lower than those based on the older and more traditional WMLS-R single data-point method. Clearly, greater confidence can be placed in the WMLS-R NU bootstrap-based norm curves.

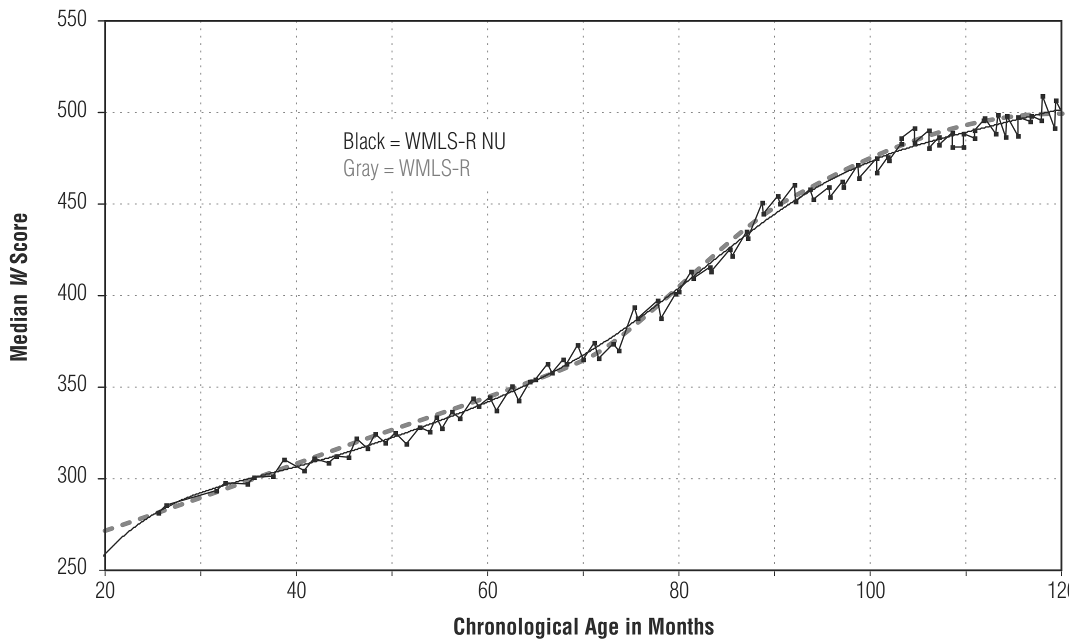


Figure 7.
Comparison of possible WMLS-R (gray) and WMLS-R NU (black) Letter-Word Identification REF W *norm curves.*

Note. Connected data points are actually connected bootstrap sticks/windows (see unconnected sticks/windows in Figure 6).

Another point where the WMLS-R and WMLS-R NU Letter-Word Identification norm curves are noticeably different is from approximately 20 to 30 months. The WMLS-R point-based curve solution trends are noticeably higher than the WMLS-R NU curve for this age range. It is well known among applied psychometricians that fitting norm curves at the youngest and oldest ages are the most problematic. When fitting curves to a set of continuous data points surrounded by other data points (e.g., the data points between 60 and 80 months in Figure 2), not only are the specific data-point values within this range used by the curve-fitting algorithms to generate possible solutions, but also information from the data points before 60 months and immediately following 80 months contribute information to the computational algorithm.

However, as can be seen in Figure 2, the first data point has no succeeding or prior data points that contribute information to fitting a proper curve through this first point, the second data point, etc. Conversely, at the oldest ages for a test's norms, the last data point does not similarly benefit from information from data beyond the last data point. As a result, there is considerable uncertainty surrounding the initial starting point (and final ending point) and the shape of the fitted norm curves at the youngest and oldest ages, as norm curves typically are extrapolated slightly beyond the extreme data points available. As a result, curve fitting becomes more art than science at the extremes of norm tables. However, as can be seen in Figure 6, when bootstrap-based confidence bands are the source data for curve fitting, the general trends of the first (and final) sets of sample statistics are more apparent. In the case of the WMLS-R NU Letter-Word Identification example presented in Figures 6 and 7, greater certainty was placed in a lower WMLS-R NU norm curve solution between 20 and approximately 36 months.

Illustration: Letter-Word Identification Example

Given that greater confidence can be placed in the WMLS-R NU bootstrap-based norm curve solutions (as illustrated in Figures 6 and 7), what do these differences mean for WMLS-R/WMLS-R NU score differences? One example follows.

Using the same 35- to 65-month age-span example described previously, a lower (and more precise) set of WMLS-R NU Letter-Word Identification REF *W* scores will produce the following, given the same obtained WMLS-R/WMLS-R NU *W* score (e.g., 325) for an individual.

- Higher age equivalents, as drawing a horizontal line from the *y*-axis value corresponding to 325 will intersect the WMLS-R gray norm curve earlier on the *x*-axis (which, when a vertical line is dropped down to the *x*-axis, the intersection provides the corresponding age equivalent) than its intersection with the lower black WMLS-R NU norm curve. If the WMLS-R NU curve is higher than the WMLS-R norm curve, the converse will hold true (providing lower WMLS-R NU age equivalents).
- Assuming no difference in the smoothed standard deviations for Letter-Word Identification, for the same Letter-Word Identification *W* score (e.g., 325) for an individual between 35 and 65 months of age, the lower WMLS-R NU REF *W* norm curve will result in higher measures of relative standing (e.g., SS, PR). For example, as can be seen in Figure 7, the normative or average REF *W* score for an individual with a chronological age of 50 months is approximately 325 (WMLS-R) and 312 (WMLS-R NU), respectively.[7] With an obtained *W* score of 325, the subject is "on norm" or average for his or her age when using the WMLS-R norm curve, which corresponds to a standard score (SS) of 100 and percentile rank (PR) of 50. Conversely, the same obtained *W* score is +13 points higher than the WMLS-R NU REF *W* value of 312, which indicates the subject is performing above the norm. The exact SS (>100) and PR (>50) for this latter example depend on the *SD* associated with scores that are above the REF *W* for 50-month-old individuals (see the *WJ III Technical Manual* [McGrew & Woodcock, 2001] for an explanation of calculation of measures of relative standing for scores above and below the normative REF *W* score for each age). The converse holds for situations where WMLS-R NU REF *W* norm curves are higher than the corresponding WMLS-R norm curve—the subjects, given the same *W* score, would obtain lower SS and PR scores.

[7] REF *W* values for specific ages are found by ascertaining the *W* score on the *y*-axis that corresponds to each chronological age value on the *x*-axis of the fitted norm curve (the intersection of the *x*/*y* values on the fitted curve).

It is important to remember that derived metrics of relative standing (e.g., SS, PR) are based on the calculation of the standard *z*-score formula where:

$$z = (\text{observed } W - \text{REF } W) / SD \qquad (1.1)$$

Using this formula, it can be seen that individuals who obtain the same observed *W* score on the Letter-Word Identification test may receive different WMLS-R/WMLS-R NU relative metric scores (e.g., SS, PR) as a function of either: (a) higher or lower smoothed WMLS-R NU REF *W* norm curves, (b) higher or lower smoothed WMLS-R NU *SD* norm curves, and/or (c) the possible interaction of both a and b.

The use of bootstrap resampling procedures allowed for the incorporation of estimates of uncertainty and potential bias in the sample data used in the calculation of the WMLS-R NU norms. As a result, the WMLS-R NU norms represent a technological advancement in the development of test norms. The WMLS-R NU norms and resultant scores, when compared to the WMLS-R, are more precise estimates of an individual's tested performance. WMLS-R/WMLS-R NU REF *W* and *SD* normative curves may or may not have changed, depending on the specific test or cluster, the developmental status of the tested individual (age or grade), and/or the type of norm bases used (age or grade norms).

Median Score Differences Between the WMLS-R and WMLS-R NU Tests

To assess the average score differences between the WMLS-R and WMLS-R NU norms, the WMLS-R test scores for all 8,782 norm subjects were calculated using both the WMLS-R and WMLS-R NU scoring programs. Age-based standard scores (SS) were calculated for each test using both sets of norms. The WMLS-R set of standard scores for each norm subject was then subtracted from the WMLS-R NU standard scores (WMLS-R NU SS – WMLS-R SS = WMLS-R/WMLS-R NU SS Difference). A negative SS difference score would indicate that, for the same norm subject, his or her WMLS-R NU SS was lower. A positive SS difference score would indicate that, for the same norm subject, his or her WMLS-R NU SS was higher.

The average (median) WMLS-R/WMLS-R NU SS differences for each test for each of the 25 norm technical age groups (i.e., ages 2, 3, 4, etc.) were then plotted on a graph (as a function of average chronological age), and polynomial curve fitting procedures were employed to generate smoothed curves that best fit the median WMLS-R/WMLS-R NU SS differences across age. These smoothed curves provide the optimal estimates of the WMLS-R/WMLS-R NU SS difference parameters.

The final average WMLS-R/WMLS-R NU SS difference estimates are reported (by chronological age) in Table 7. Examiners can use the information presented in Table 7 to anticipate the typical SS differences between the WMLS-R and the WMLS-R NU when switching from the WMLS-R to WMLS-R NU scoring programs. Remember that these are *average* differences due to the differences in the WMLS-R and WMLS-R NU norm calculation procedures.

Table 7.
Average (Median) Standard Score (M = 100, SD = 15) Differences for WMLS-R NU Test Scores (Calculated for All Norm Subjects [by Age] Based on WMLS-R and WMLS-R NU Norms)

	Chronological Age Groups (in years)																
	Preschool (P)				School-Age (S)												
Test	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Picture Vocabulary	**–5**	**–2**	**–2**	**–2**	**–2**	**–3**	**–3**	**–3**	**–3**	**–3**	**–2**	**–2**	**–2**	**–2**	**–2**	**–2**	**–2**
Verbal Analogies			**–4**	**–2**	**–2**	–1	0	0	0	1	1	1	1	1	1	1	1
Letter-Word Identification	**–7**	**–5**	**–4**	**–4**	**–3**	0	0	0	–1	**–2**	**–2**	**–2**	**–2**	–1	–1	0	0
Dictation		**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–2**	0	**2**
Understanding Directions	1	1	0	0	0	–1	–1	**–2**	**–2**	**–2**	**–2**	**–2**	**–2**	–1	0	1	1
Story Recall	–1	**–2**	**–3**	**–3**	**–2**	**–2**	–1	–1	–1	–1	–1	0	0	0	0	0	0
Passage Comprehension			**–10**	**–5**	**–2**	**–2**	**–2**	**–2**	**–2**	**–2**	**–2**	–1	–1	–1	0	0	0

	Adult (A)									*SD DIFF*[a]		
Test	**19**	**20–29**	**30–39**	**40–49**	**50–59**	**60–69**	**70–79**	**80–89**	**90+**	**P**	**S**	**A**
Picture Vocabulary	**–2**	–1	–1	–1	–1	–1	**–2**	**–2**	**–3**	2	1	2
Verbal Analogies	1	1	0	–1	–1	–1	0	**2**	**4**	7	2	3
Letter-Word Identification	1	0	**–2**	**–4**	**–4**	**–3**	**–2**	**–2**	**–2**	11	5	4
Dictation	**2**	–1	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	**–3**	2	5	4
Understanding Directions	1	1	–1	**–2**	**–3**	**–3**	**–3**	**–3**	**–3**	11	14	11
Story Recall	0	0	0	**–2**	**–3**	**–3**	**–3**	**–3**	**–3**	2	1	2
Passage Comprehension	0	0	–1	**–2**	**–2**	**–3**	**–3**	**–2**	**–2**	5	5	4

Note: Negative difference indicates that average WJ III NU standard score is lower. Positive value indicates that average NU standard score is higher. Bold values designate average differences that are operationally defined as significant (<–2 or >+2).
[a] *SD(DIFF)* = Standard deviation of WJ III NU SS differences for broad Preschool (P), School-Age (S), and Adult (A) age ranges.

Average Differences: General Findings and Trends

In general, a review of the information in Table 7 indicates that when a significant average WMLS-R/WMLS-R NU SS difference is present, typically the difference is that the WMLS-R NU SS is lower. A review of the table also reveals a trend for the WMLS-R/WMLS-R NU SS differences to be largest at both ends since the WMLS-R NU SS scores are typically lower at the youngest and oldest age groups, particularly the former.

School-Age Trends. The results for the school-age population (ages 6 through 18) reveals significant differences between WMLS-R and WMLS-R NU scores in all seven tests. However, when compared to the preschool (ages 2 through 5) and adult (19 years and above) age ranges, the magnitude of WMLS-R/WMLS-R NU score differences are the least different in the school-age population (ages 6 through 18).

Preschool and Adult Age Group Trends. A review of the results in Table 7 for ages 2 to 5 (Preschool) and 19 and above (Adult) indicates that the most noticeable WMLS-R/WMLS-R NU SS differences (greater than or equal to –4 SS points) are to be expected at the youngest and oldest age groups for some, but not all, tests. Also, in general, the differences become larger as the subjects become younger (e.g., Letter-Word Identification average SS differences are –4 for ages 4 to 5, –5 at age 3, and –7 at age 2).

Range of Average Differences: General Findings and Trends

The last three columns of Table 7 are the average standard deviations (*SD*) of the obtained WMLS-R/WMLS-R NU SS differences (*SD* DIFF) for the three broad age-based norm groups (P = Preschool, S = School-Age, A = Adult). For each test, the WMLS-R/WMLS-R NU SS *SD* DIFF values designate the range within which 68% of the WMLS-R/WMLS-R NU SS differences occur. The results for Letter-Word Identification are used here to demonstrate how to use and interpret this information.

As reported in Table 7, the *SD* DIFF for Letter-Word Identification is 11 SS points (Preschool), 5 SS points (School-Age), and 4 SS points (Adult), respectively. When combined with the average SS differences reported for each chronological age, the following illustrative interpretations are appropriate. In each example, the average WMLS-R/WMLS-R NU SS difference indicates that the WMLS-R NU Letter-Word Identification scores are lower than the WMLS-R Letter-Word Identification scores.

Age 5. The expected average SS difference at age 5 is –4 SS points, with 68% of the difference scores being within a range of 11 SS points. This produces an expected range of scores from –16 SS (–4 minus 11) to +7 SS points (–4 plus 11).

Age 12. The expected average SS difference at age 12 is –2 SS points. The range within which 68% of the difference scores occur is 5 SS points. The proper interpretation is that the average Letter-Word Identification WMLS-R NU SS at age 12 is expected to be –2 SS points, and 68% of the scores will range from –7 SS (–2 minus 5) to +3 SS points (–2 plus 5).

Age 45. The expected average SS difference at age 45 is –4 SS points. The range within which 68% of the difference scores are found is 4 SS points. Thus, the proper interpretation of Letter-Word Identification at age 45 is that, on average, WMLS-R/WMLS-R NU SS differences are expected to be –4 SS points but can range from –8 SS (–4 minus 4) to 0 SS points (–4 plus 4).

A review of the *SD* DIFF information in Table 7 indicates that no single rule of thumb can be applied across all WMLS-R/WMLS-R NU test score comparisons. The 68% range of typical WMLS-R/WMLS-R NU SS difference scores varies as a function of tests and age groups and, for some tests, varies across age groups for the same test. Users should consult the complete set of information in Table 7 to ascertain the expected average WMLS-R/WMLS-R NU SS differences and general range of differences typical for each test.

Summary

The WMLS-R Normative Update is a recalculation of the original WMLS-R normative data based on the final U.S. Bureau of Census statistics, which were released in 2005. No new normative data were gathered. The WMLS-R NU norms replace the original WMLS-R norms, which were based on the year 2000 census projections that were published in 1996. Changes to the U.S. population demographics provided the initial impetus for an investigation of how such changes would be reflected in a recalculation of the norms.

With the exceptions of Understanding Directions and Story Recall (see McGrew, Schrank & Woodcock, 2007), the original WMLS-R obtained *W* scores for all tests are identical for subjects in the calculation of the WMLS-R and WMLS-R NU norms. What is different are the weights applied to each subject's test *W* score for the WMLS-R and WMLS-R NU norms. In simple terms, how much each norm subject's performance influenced the calculation of the average or typical score for any test or cluster shifted from the WMLS-R to WMLS-R NU to more accurately reflect each subject's relative contribution to the final year 2000 U.S. census statistics.

Clearly one of the most noticeable changes between the year 2000 U.S. population projections and the year 2000 U.S. population final statistics is the increased proportion of U.S. individuals classified as Hispanic. The scores for Hispanic subjects are now weighted more (by approximately 20% to 30% for each Hispanic subject) in the calculation of the NU norms. Additionally, the number of home-schooled students has significantly increased, resulting in a greater weight being placed on home-schooled subjects in the norm basis; home-schooled subjects count about 44% more in the WMLS-R NU norms than they did in the WMLS-R school-age norms.

Significant enhancements in the procedures used to calculate the raw data used for norm curve fitting were incorporated in the WMLS-R NU. For calculation of the WMLS-NU norms, greater certainty of the raw data points used to generate norm curves was introduced via the use of a statistical technique known as the bootstrap sampling procedure—a method of assigning measures of accuracy to sampling data. The combined effect of this technique with the updated subject weights provides a more current and accurate comparison of an individual's scores to the U.S. population, allowing users of the WMLS-R to have greater confidence in the accuracy of the WMLS-R NU-based scores.

The *Ethical Principles of Psychologists and Code of Conduct of the American Psychological Association* (APA, 2002) suggests that assessments, intervention decisions, and recommendations should be based on an instrument's most current norms (Standard 9.08). This principle suggests that examiners should update to the WMLS-R NU norms as soon as practicable. However, in limited instances where growth and change across time is being measured, the original WMLS-R norms should be used as the postchange measure, but only for that purpose.

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