Psychological Assessment
2006, Vol. 18, No. 2, 174–181

1040-3590/06/$12.00 DOI: 10.1037/1040-3590.18.2.174

Development of Demographic Norms for Four New WAIS-III/WMS-III Indexes

Rael T. Lange
Riverview Hospital

Gordon J. Chelune
Cleveland Clinic Foundation

Michael J. Taylor
University of California, San Diego

Todd S. Woodward
Riverview Hospital

Robert K. Heaton
University of California, San Diego

Following the publication of the third edition Wechsler scales (i.e., WAIS-III and WMS-III), demographically corrected norms were made available in the form of a computerized scoring program (i.e., *WAIS-III/WMS-III/WIAT-II Scoring Assistant*). These norms correct for age, gender, ethnicity, and education. Since then, four new indexes have been developed: the WAIS-III General Ability Index, the WMS-III Delayed Memory Index, and the two alternate Immediate and Delayed Memory Indexes. The purpose of this study was to develop demographically corrected norms for the four new indexes using the standardization sample and education oversample from the WAIS-III and WMS-III. These norms were developed using the same methodology as the demographically corrected norms made available in the *WAIS-III/WMS-III/WIAT-II Scoring Assistant*.

Keywords: WAIS-III, WMS-III, demographic norms, standardization sample

It is well recognized that certain demographic variables such as age, education, gender, and ethnicity can have a significant influence on neuropsychological test performance. Consequently, normative data for neuropsychological tests are routinely corrected by one or more demographic variables (e.g., Axelrod & Goldman, 1996; Heaton, Grant, & Matthews, 1991; Heaton, Miller, Taylor, & Grant, 2004; Heaton, Ryan, Grant, & Matthews, 1996; Lezak, 1995; Mitrushina, Boone, & D'Elia, 1998; Spreen & Strauss, 1998; Yeudall, Reddon, Gill, & Stefanyk, 1987; Vanderploeg, Axelrod, Sherer, Scott, & Adams, 1997). The influence of demographic variables such as age and education on the Wechsler Adult Intelligence Scale–Revised (WAIS-R; Wechsler, 1981) has been well documented in healthy adult (e.g., Heaton, 1992; Kaufman, McLean, & Reynolds, 1988; Matarazzo & Herman, 1984; Ryan, Paolo, & Findley, 1991; Reynolds, Chastain, Kaufman, & McLean, 1987; Shores & Carstairs, 2000) and elderly populations (e.g., Malec et al., 1992). The impact of gender, occupation, and ethnicity on WAIS–R performance has also been established (e.g., Shores & Carstairs, 2000; Kaufman, McLean, & Reynolds, 1988; Reynolds, Chastain, Kaufman, & McLean, 1987). Although the WAIS–R has received the majority of attention of the Wechsler batteries, the influence of demographic variables, other than age, on Wechsler Memory Scale–Revised (WMS-R; Wechsler, 1987) performance has also been recognized (e.g., Heaton et al., 1996; Heaton & Marcotte, 2000; Shores & Carstairs, 2000).

The third edition of the Wechsler adult intelligence and memory scales (WAIS-III, WMS-III; Wechsler, 1997a, 1997b) are now widely used by clinicians and researchers. The initial publication of the WAIS-III and WMS-III included normative data stratified by 13 age groups. The availability of norms that adjust for additional demographic variables (i.e., education, gender, and ethnicity) soon followed in the form of a computerized scoring package (i.e., *WAIS-III/WMS-III/WIAT-II Scoring Assistant*; The Psychological Corporation, 2001). The need to develop demographically corrected scores for both the WAIS-III and WMS-III batteries was established by Taylor and Heaton (2001) and Heaton, Taylor, and Manly (2003), who demonstrated that gender, ethnicity, and education, in addition to age, significantly affected false positive error rates when WAIS-III and WMS-III results were used to classify cognitive impairment. Since the release of the *WAIS-III/WMS-III/*

Rael T. Lange, Todd S. Woodward, Riverview Hospital; Gordon J. Chelune, Cleveland Clinic Foundation; Michael J. Taylor, Robert K. Heaton, University of California, San Diego.

Gordon J. Chelune is now at University of Utah.

Portions of these data were presented at the National Academy of Neuropsychology annual conference, October 2004, Seattle, WA. We thank The Psychological Corporation for permission to use the data from the standardization sample, education oversample, and clinical sample of the following: the *Wechsler Adult Intelligence Scale–Third Edition*.

Correspondence concerning this article should be addressed to Rael T. Lange, Ph.D., Riverview Hospital, Department of Research, Room 124—ADMIN Building, 2601 Lougheed Highway, Coquitlam, British Columbia V3C 4J2, Canada. E-mail: rlange@bcmhs.bc.ca

WIAT-II Scoring Assistant, four new WAIS-III and WMS-III index scores have been developed. These include the WAIS-III General Ability Index (GAI; Tulsky, Saklofske, Wilkins, & Weiss, 2001) and three new WMS-III memory indexes (Tulsky, Chelune, & Price, 2004); the latter include the Delayed Memory Index (DMI), an alternate Immediate Memory Index (IMI_{alt}), and an alternate Delayed Memory Index (DMI_{alt}).

The six-subtest GAI was designed to measure global intellectual functioning and is considered a "reasonable substitute" (Tulsky et al., 2001, p. 567) for the 11-subtest FSIQ. The GAI is composed of the unweighted sum of scaled scores of the six subtests that contribute to the Verbal Comprehension and Perceptual Organization Indexes (i.e., Information, Vocabulary, Similarities, Picture Completion, Block Design, & Matrix Reasoning). Tulsky and colleagues present data from the WAIS-III standardization sample for converting sum of scaled scores to GAI scores. The GAI should not be viewed as a short form of FSIQ. The GAI is a composite measure of verbal and nonverbal intellectual functioning and does not include the Working Memory Index (WMI) or the Processing Speed Index (PSI) that contribute to the FSIQ. Thus, the GAI covers only two of the four domains assessed by the WAIS-III. It is thought that the GAI is less susceptible to neurological insult compared with FSIQ (Tulsky et al., 2001) because it does not include those subtests that comprise the WMI and PSI, which tend to be most sensitive to brain impairment (e.g., Donders, Tulsky, & Zhu, 2001; Fisher, Ledbetter, Cohen, Marmor, & Tulsky, 2000; Hawkins, 1998; Martin, Donders, & Thompson, 2000; The Psychological Corporation, 1997). In partial support of this notion, Iverson, Lange, Viljeon, and Brink (2006) demonstrated that GAI was less susceptible to the effects of brain damage and psychiatric illness when compared to FSIQ; however, the decrease in FSIQ scores was primarily the result of low PSI rather than WMI.

In a more recent addition to WMS-III test interpretation, Tulsky, Chelune, and Price (2004) developed the Delayed Memory Index (DMI). The DMI was developed as an alternative index to the General Memory Index (GMI) to measure delayed memory ability. The DMI consists of the unweighted sum of scaled scores on four WMS-III subtests: Logical Memory II, Visual Paired Associates II, Faces II, and Family Pictures II. The DMI was developed in response to several methodological limitations identified when comparing the traditional Immediate Memory Index (IMI) and GMI on the WMS-III. First, there is a lack of parallelism between IMI and GMI that makes direct comparisons between the two scores problematic due to the presence of the recognition component in GMI. Second, the inclusion of a recognition component in GMI potentially introduces extraneous variance not present in IMI. Recognition scores are not normally distributed and are limited by extreme ceiling effects (see Tulsky, Chiaravalloti, Palmer, & Chelune, 2003, and Tulsky et al., 2004, for a more comprehensive discussion). Tulsky and colleagues further developed alternative DMI (i.e., DMI_{alt}) and IMI (i.e., IMI_{alt}) scores that replaced the Faces subtest with the Visual Reproduction subtest. These alternative indexes were developed based on research (e.g., Chiaravalloti, Tulsky, & Glosser, 2004; Millis, Bowers, Malina, & Ricker, 1999; Price, Tulsky, Millis, & Weiss, 2002; Wilde et al., 2003; Tulsky, Ivnik, Price, & Wilkins, 2003) demonstrating that the Faces subtests "had low communality coefficients with the visual memory factor, as well as theoretical considerations about mixing recognition with recall tasks and the use of facial stimuli" (Tulsky et al., 2004). Tulsky et al. present data from the WAIS-III/WMS-III costandardization sample for converting sum of scaled scores to DMI, DMI_{alt}, and IMI_{alt}.

To date, demographically corrected norms for GAI, DMI, DMI_{alt}, and IMI_{alt} have not been developed. As such, these indexes are somewhat limited for current clinical use by those clinicians who interpret WAIS-III and WMS-III demographically corrected scores. The purpose of this investigation was to develop demographically corrected norms for GAI, DMI, DMI_{alt}, and IMI_{alt} using the WAIS-III and WMS-III standardization sample and education oversample.

Method

Participants

Data from the WAIS-III and WMS-III standardization and educational oversample were obtained with permission from the Psychological Corporation, a Harcourt Assessment company.[1] The education oversample data were collected for further research "investigating the relationship between cognitive abilities and educational level" (The Psychological Corporation, 1997, p.19). The oversample includes a greater proportion of ethnic minorities with less education, and was specifically included to reduce concerns which have been made pertaining to the use of regression-based norms for demographic correction (Fastenau & Adams, 1996). Sampling details, including stratified sampling and exclusion criteria for the standardization sample and educational oversample are described in the WAIS-III/WMS-III technical manual (The Psychological Corporation, 1997).

All participants between 16 and 19 years of age were excluded because years of formal education reported for these participants was that of their parents, not their actual years of education. Individuals whose ethnicity was classified as "other" were further excluded because this group was not sufficiently represented in the subject sample. A total of 2232 individuals were included in the analyses. Of this sample, 1025 individuals had WMS-III data. Descriptive statistics for the final participants are presented in Table 1.

Participants also included 137 members of the WAIS-III clinical field trials sample (The Psychological Corporation, 1997). The clinical group was comprised of patients with six different neuropsychiatric disorders; Alzheimer's disease (n = 37), Huntington's disease (n = 15), Parkinson's disease (n = 11), Korsakoff's syndrome (n = 12), traumatic brain injury (n = 19), and schizophrenia (n = 43). Demographic characteristics of the clinical samples by group are provided in the WAIS-III/WMS-III Technical Manual (The Psychological Corporation, 1997).

Measures & Procedure

Measures were the WAIS-III General Ability Index (GAI; Tulsky et al., 2001) and the WMS-III Delayed Memory Index (DMI), alternate Delayed Memory Index (DMI_{alt}), and alternate Immediate Memory Index (IMI_{alt}; Tulsky et el., 2004).

Fractional polynomial regressions were used to generate equations that convert age-adjusted GAI, DMI, DMI_{alt}, and IMI_{alt} scores to T scores that are more fully corrected for demographic influences. Optimal fractional polynomial regression equations were determined by the method employed by Royston and Altman (1994), using the statistical package Stata (Stata Corporation, College Station, TX). Briefly, this approach uses an iterative

[1] *Wechsler Adult Intelligence Scale–Third Edition*. Copyright © 1997 by Harcourt Assessment, Inc. Reproduced with permission. All rights reserved. *Wechsler Memory Scale–Third Edition*. Copyright © 1997 by Harcourt Assessment, Inc. Reproduced with permission. All rights reserved.

Table 1
Descriptive Statistics (Percent) of Participant Samples by Demographics

	Total available sample[a]		Standardization sample		Education oversample	
	WAIS-III	WMS-III	WAIS-III	WMS-III	WAIS-III	WMS-III
Age (yrs)						
20–24	11.3	10.5	9.8	9.7	23.7	14.5
25–29	10.1	9.3	9.6	8.3	14.3	14.0
30–34	10.1	11.7	9.6	10.6	14.3	17.4
35–44	10.4	10.7	9.8	9.0	15.9	19.2
45–54	9.6	8.9	9.6	8.7	9.8	9.9
55–64	9.0	8.7	9.6	9.8	4.1	2.9
65–69	8.9	8.1	9.8	9.4	1.6	1.7
70–74	9.2	9.3	10.0	10.3	2.9	4.1
75–79	9.3	9.5	10.0	10.3	4.1	5.2
80–84	7.4	7.3	7.5	7.3	6.9	7.6
85–89	4.7	6.0	4.9	6.6	2.4	3.5
Education (yrs)						
≤ 8	15.8	17.6	12.1	12.5	45.7	42.4
9–11	14.2	16.5	12.4	13.4	28.2	32.0
12	32.2	29.7	35.5	34.9	5.3	3.5
13–15	20.7	20.6	22.1	23.0	9.0	8.7
≥ 16	17.2	15.7	17.8	16.2	11.8	13.4
Gender						
Male	46.6	46.9	46.2	46.0	49.8	51.7
Female	53.4	53.1	53.8	54.0	50.2	48.3
Ethnicity						
African American	13.4	14.4	10.8	10.8	34.7	32.6
Hispanic	13.4	8.5	6.6	7.0	19.2	15.7
Caucasian	78.5	77.1	82.5	82.2	46.1	51.7
Region						
South	36.9	36.5	36.3	34.9	41.2	44.2
North central	25.4	24.0	25.6	24.5	24.5	21.5
Northeast	15.7	16.9	17.0	19.1	5.3	5.8
West	22.0	22.6	21.1	21.5	29.0	28.5

Note. Total available sample: WAIS-III, n = 2232; WMS-III, n = 1025; Standardization sample: WAIS-III, n = 1987; WMS-III, n = 853; Education oversample: WAIS-III, n = 245; WMS-III, n = 172; All data are derived from the standardization sample and educational oversample of the following: *Wechsler Adult Intelligence Scale–Third Edition*. *Wechsler Memory Scale–Third Edition.*
[a] Participants were excluded if <20 years old and/or ethnicity was classified as "Other."

algorithm for evaluating the influence of combinations of predictors, which have been transformed using a restricted set of predetermined powers (i.e., −2, −1, −0.5, 0.5, 1, 2, 3). The algorithm compares all sets of predictors using these transformations to generate the final optimal fit. Royston's and Altman's method for selecting optimal fractional polynomials was chosen due to its improved accuracy in curve fitting. For a more comprehensive discussion regarding this statistical method, the interested reader is referred to Heaton et al. (2003).

Results

Descriptive statistics for the four WAIS-III and WMS-III indexes by gender, education, ethnicity, and region of the country are presented in Table 2. There was a significant main effect on all four indexes for education (all $p < .001$), ethnicity (all $p < .001$) and gender (IMI_{alt}, $p = .004$; GAI, DMI & DMI_{alt}, all $p < .001$). For region of the country, there was a significant main effect for GAI ($p < .001$), but not for DMI ($p = .164$), DMI_{alt} ($p = .469$), or IMI_{alt} ($p = .066$).

Overall, male subjects performed significantly higher than females on GAI ($d = 0.22$, small effect), but significantly lower on DMI ($d = 0.33$, small to medium effect), DMI_{alt} ($d = 0.25$, small effect), and IMI_{alt} ($d = 0.18$, small effect). Tukey's post hoc analyses revealed a linear relationship between level of education and GAI ($d = 2.05$, large effect) and the three memory scores (DMI, $d = 0.90$, DMI_{alt}, $d = 0.96$, IMI_{alt}, $d = 1.11$, all large effects).[2] With respect to region of the country, individuals from western and southern United States had the highest and lowest GAI scores respectively ($d = 0.38$, small to medium effect). Significantly higher GAI and memory index scores were obtained by Caucasian participants, followed by individuals of Hispanic and African American ethnicity (range: $d = 0.76$ to $d = 1.13$, large effect).

Using data from the WAIS-III and WMS-III standardization sample and educational oversample, fractional polynomial regression was used to generate optimal regression equations for GAI, DMI, DMI_{alt}, and IMI_{alt}. Equations were derived using all participants with avail-

[2] Cohen's effect sizes were calculated between the highest and lowest mean scores for each demographic variable (i.e., small effect = 0.2, medium effect = 0.5, large effect = 0.8).

Table 2
Descriptive Statistics for Age-corrected GAI, DMI, DMI_{alt}, and IMI_{alt} Scores by Demographic Variables

	GAI		DMI		DMI_{alt}		IMI_{alt}	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Education								
≤ 8	87.6	10.9	93.9	13.2	93.7	13.3	92.4	13.8
9–11	91.3	11.7	92.8	14.5	92.6	14.0	91.1	14.6
12	98.9	12.9	100.5	14.4	100.2	14.9	100.1	14.2
13–15	103.6	12.8	103.4	14.6	104.0	14.2	103.5	13.3
≥ 16	112.8	13.7	105.8	14.4	106.2	14.4	106.1	12.5
Gender								
Male	101.1	15.1	96.9	14.5	97.6	14.6	97.5	14.1
Female	97.9	14.7	101.8	15.1	101.3	15.3	100.2	15.2
Ethnicity								
African American	87.8	10.7	91.0	13.0	91.1	12.5	88.9	12.5
Hispanic	92.4	12.8	95.6	15.2	94.7	14.3	94.3	13.8
Caucasian	102.1	14.6	101.5	14.7	101.7	14.9	101.3	14.4
Region								
South	97.2	14.4	98.7	14.1	98.9	14.1	97.4	13.9
North central	98.9	15.2	99.1	16.1	99.2	16.0	99.3	15.8
Northeast	100.6	14.6	99.2	14.8	99.6	15.4	99.5	14.5
West	102.8	15.2	101.4	15.4	100.8	15.4	100.5	15.1

Note. Sample Size: WAIS-III, $n = 2232$; WMS-III, $n = 1025$. Participants were excluded if <20 years old and/or ethnicity was classified as "Other." GAI = General Ability Index; DMI = Delayed Memory Index; DMI_{alt} = alternate Delayed Memory Index; IMI_{alt} = alternate Immediate Memory Index. All data are derived from the standardization sample and educational oversample of the following: *Wechsler Adult Intelligence Scale–Third Edition*. *Wechsler Memory Scale–Third Edition.*

able data. Fractional polynomial regression equations were generated to predict age-adjusted GAI and memory index scores from education (in years), age (in years), and gender (male = 0, female = 1) variables.[3] Region of the country was not included in the analyses.[4] To account for the influence of ethnicity on the GAI and memory indexes, separate regression analyses were conducted for each ethnic group that was sufficiently represented in the sample (i.e., Caucasian, African American, and Hispanic). The residuals produced using the optimal fractional polynomial regression equations were converted to *T* scores with a mean of 50 and a *SD* of 10. The resulting distributions did not differ significantly from normal based on Kolmogorov–Smirnov tests, and did not significantly correlate with any of the demographic variables. The equations to convert age-adjusted GAI, DMI, DMI_{alt}, and IMI_{alt} scores (M = 100, *SD* = 15) to demographically corrected *T* scores (M = 50, *SD* = 10) are presented in Table 3. These equations can be used as a syntax file in the Statistical Package for the Social Sciences. A spreadsheet to calculate these scores may also be downloaded at *www.harcourt.com*.

Using the WAIS-III and WMS-III clinical sample, demographically corrected *T* scores were calculated for each patient. Descriptive statistics for the four new demographically corrected index scores in the clinical sample are presented in Table 4. Significant main effects were found on all four indexes across the six diagnostic groups (all $p < .001$). Tukey's post hoc analyses revealed few differences between clinical groups for GAI. Only patients with Alzheimer's dementia had lower GAI scores compared to patients with Korsakoff's syndrome and schizophrenia. For the memory indexes, there was a more complex pattern of differences between groups. These differences are detailed in Table 4. In general, patients with Alzheimer's dementia, Korsakoff's syndrome, and Huntington's disease tended to have lower scores on all three memory indexes compared to patients with Parkinson's disease, schizophrenia, and traumatic brain injury. The effect size between the lowest and highest index score across the six clinical groups was $d = 1.11$ for GAI, $d = 1.87$ for DMI, $d = 2.05$ for DMI_{alt}, and $d = 1.44$ for IMI_{alt} (all large effects).

To further explore the clinical application of the four new demographically corrected index scores, the sensitivity and specificity of the four indexes using three cutoffs (i.e., 1, 1.5, and 2 SDs) were calculated. Specificity was defined as the percent of normal healthy participants falling at or above the cutoff score. Sensitivity was defined as the percent of the clinical sample falling below the cutoff score. The specificity of the four new index scores ranged from 83.0% to 86.3% using a 1 *SD* cutoff score, 93.1% to 95.7% using 1.5 *SD*, and 97.2% to 98.8% using 2 SDs. These specificity estimates are consis-

[3] Prior to the analysis, individuals with fewer than 8 years education and greater than 16 years education were re-coded to 7 years and 17 years of education respectively. Although the Index scores used in the analysis are age-adjusted using the traditional linear method of forced-normalization, age was included in the fractional polynomial equations to make any nonlinear adjustments as necessary.

[4] Region of the country was not included in these analyses for two reasons. First, the primary consideration of this study was to generate equations that were directly comparable to the methodology previously used to develop demographically corrected scores for the traditional WAIS-III and WMS-III indexes. Region of the country was not used in these original equations. Second, region of the country was found to have little influence on the majority of index scores. The one exception to this was GAI. However, in order to maintain consistency with previously developed norms, region of the country was not used in the development of GAI demographic norms.

Table 3

Equations for Calculating Demographically Corrected T-scores for GAI, DMI, DMI_{alt} and IMI_{alt} by Ethnicity

African American	
GAI	(((((GAI − (((3.898266*(((EDUC/10)**3) − 1.508)) + (−0.032635*(((AGE)) − 44.94)) + (−2.49399*GEN) + 88.18986))) − (0.001211))/9.4485)*10) + 50).
DMI	(((((DMI − (((−121.7629*(((EDUC/10)) − 1.127)) + (113.09*(((EDUC/10))*(LN(EDUC/10)) − 0.1348)) + (−0.0391142*(((AGE)) − 44.86)) + (3.630761*GEN) + 85.30886))) − (0.00648))/12.17288)*10) + 50).
DMI_{alt}	(((((DMI_{alt} − (((−114.8844*(((EDUC/10)) − 1.127)) + (106.8583*(((EDUC/10))*(LN(EDUC/10)) − 0.1348)) + (−0.0338974*(((AGE)) − 44.86)) + (2.298026*GEN) + 86.38266))) − (0.0061))/11.8394)*10) + 50).
IMI_{alt}	(((((IMI_{alt} − (((−45.5213*(((EDUC/10)) − 1.127)) + (12.6794*(((EDUC/10)**3) − 1.432)) + (−.02956*(((AGE)) − 44.86)) + (2.6945*GEN) + 85.8565))) − (0.0072))/10.5271)*10) + 50).
Hispanic	
GAI	(((((GAI − (((6.0827*(((EDUC/10)**3) − 1.305)) + (0.0506*(((AGE)) − 41.35)) + (−2.6716*GEN) + 92.1705))) − (0.0013))/10.5844)*10) + 50).
DMI	(((((DMI − (((−34.0479*(((EDUC/10)**2) − 1.122)) + (60.8984*(((EDUC/10)**2)*(LN(EDUC/10)) − 0.1214)) + (−0.0876877*(((AGE)) − 40.98)) + (4.42541*GEN) + 88.170))) − (3.3422))/13.2567)*10) + 50).
DMI_{alt}	(((((DMI_{alt} − (((4.6407*(((EDUC/10)**3) − 1.348)) + (0.0619*(((AGE)) − 40.98)) + (2.1307*GEN) + 92.4035))) − (0.0013))/12.9592)*10) + 50).
IMI_{alt}	(((((IMI_{alt} − (((1.574201*(((EDUC)) − 11.05)) + (−0.0336571*(((AGE)) − 40.98)) + (3.340238*GEN) + 94.01989))) − (0.0062))/12.2218)*10) + 50).
Caucasian	
GAI	(((((GAI − (((3.117279*(((EDUC)) − 12.49)) + (0.0752644*(((AGE)) − 54.66)) + (−2.687989*GEN) + 103.5236))) − (−0.012320))/12.08526)*10) + 50).
DMI	(((((DMI − (((−21.75817*(((EDUC/10)**−1) − 0.8123)) + (0.0036585*(((AGE)) − 55.48)) + (6.456566*GEN) + 99.04248))) − (−0.00095))/13.73446)*10) + 50).
DMI_{alt}	(((((DMI_{alt} − (((1.72531*(((EDUC)) − 12.31)) + (0.0067446*(((AGE)) − 55.48)) + (5.215447*GEN) + 98.90653))) − (−0.00238))/14.04062)*10) + 50).
IMI_{alt}	(((((IMI_{alt} − (((−21.1152*(((EDUC/10)** − 1) − 0.8123)) + (0.0118323*(((AGE)) − 55.48)) + (5.504517*GEN) + 98.90822))) − (−0.1019))/12.53416)*10) + 50).

Note. EDUC = Education in years (if education less than 7 = 7; education greater than 17 = 17); GEN = gender (male = 0, female = 1); AGE = in years (range = 20–89 years); ** = Exponentiation. The preceding term is raised to the power of the following term, e.g., 5**3 = 5 to the power of 3 = 5 × 5 × 5; LN = Returns the natural logarithm of a number; GAI = General Ability Index; DMI = Delayed Memory Index; DMI_{alt} = alternate Delayed Memory Index; IMI_{alt} = alternate Immediate Memory Index. A spreadsheet to calculate these scores can be downloaded at www.harcourt.com. All data are derived from the standardization sample and educational oversample of the following: *Wechsler Adult Intelligence Scale–Third Edition*. *Wechsler Memory Scale–Third Edition.*

tent with what would be expected from a normal distribution. In the combined clinical sample, sensitivity values were consistently lower for GAI using all three cutoff scores (1 *SD* = 54.5%; 1.5 *SD* = 32.6%; 2 *SD* = 12.1%) compared to the three memory indexes (1 *SD* = 76.5% to 78.8%; 1.5 *SD* = 62.9% to 65.9%; 2 SDs = 50.0% to 54.5%). A detailed breakdown of the sensitivity of the four indexes (using the 1 *SD* and 2 *SD* cutoff) in the six diagnostic groups is presented in Table 5.

Table 4

Descriptive Statistics and Group Comparisons of GAI, DMI, DMI_{alt}, and IMI_{alt} Demographically Corrected T-scores by Clinical Group

WAIS-III/WMS-III Index	HD	KS	PD	SCHZ	DAT	TBI
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
General ability index	38.3_{a}	43.4_{b}	39.6_{a}	43.6_{b}	33.8_{a}	39.4_{a}
	(8.9)	(7.8)	(10.0)	(10.3)	(7.4)	(8.9)
Delayed memory index	28.1_{ac}	23.2_{a}	37.4_{b}	37.0_{b}	19.8_{a}	34.7_{bc}
	(7.9)	(3.6)	(13.0)	(11.7)	(5.8)	(12.4)
Delayed memory $index_{alt}$	29.8_{bc}	22.9_{ac}	37.5_{b}	38.1_{b}	20.1_{a}	35.6_{b}
	(8.6)	(4.1)	(12.4)	(11.1)	(6.5)	(13.4)
Immediate memory $index_{alt}$	24.7_{ac}	29.5_{abc}	36.0_{b}	35.4_{b}	18.8_{a}	35.4_{bc}
	(7.9)	(4.0)	(15.6)	(12.8)	(8.3)	(15.1)

Note. Values across rows with different subscripts are significantly different, $p < .01$. Total Sample, $n = 137$; HD = Huntington's Disease ($n = 15$); KS = Korsakoff's Syndrome (WAIS-III, $n = 12$; WMS-III, $n = 10$); PD = Parkinson's Disease (WAIS-III, $n = 11$; WMS-III, $n = 10$); SCHZ = Schizophrenia (WAIS-III, $n = 43$; WMS-III, $n = 41$); DAT = Dementia of the Alzheimer's type: mild (WAIS-III, $n = 37$; WMS-III, $n = 35$); TBI = Traumatic Brain Injury ($n = 19$). All data are derived from the clinical sample of the following: *Wechsler Adult Intelligence Scale–Third Edition*. *Wechsler Memory Scale–Third Edition.*

Table 5
Sensitivity Estimates of Demographically Corrected GAI, DMI, DMI_{alt}, and IMI_{alt} Using 1, 1.5, and 2 SD Cutoff Scores by Clinical Group

Clinical Group	Cutoff	GAI	DMI	DMI_{alt}	IMI_{alt}
Huntington's disease	1 *SD*	53.3	100	86.7	100
	1.5*SD*	40.0	66.7	66.7	93.3
	2 *SD*	20.0	60.0	46.7	66.7
Korsakoff's syndrome	1 *SD*	33.3	100	100	100
	1.5*SD*	16.7	100	100	90.0
	2 *SD*	8.3	100	100	40.0
Parkinson's disease	1 *SD*	54.5	50.0	60.0	60.0
	1.5*SD*	27.3	50.0	40.0	40.0
	2 *SD*	18.2	20.0	20.0	20.0
Schizophrenia	1 *SD*	41.9	65.9	61.0	63.4
	1.5*SD*	20.9	41.5	43.9	46.3
	2 *SD*	0	29.3	24.4	39.0
Alzheimer's dementia	1 *SD*	81.1	100	97.1	94.3
	1.5*SD*	51.4	97.1	94.3	94.3
	2 *SD*	27.0	91.4	91.4	91.4
Traumatic brain injury	1 *SD*	52.6	63.2	63.2	68.4
	1.5*SD*	31.6	47.4	42.1	42.1
	2 *SD*	10.5	26.3	26.3	36.8

Note. *Sensitivity* is defined as the percent of the clinical sample falling below the cutoff score. Total Sample, $n = 137$; Huntington's Disease ($n = 15$); Korsakoff's Syndrome (WAIS-III, $n = 12$; WMS-III, $n = 10$); Parkinson's Disease (WAIS-III, $n = 11$; WMS-III, $n = 10$); Schizophrenia (WAIS-III, $n = 43$; WMS-III, $n = 41$); Dementia of the Alzheimer's type: mild (WAIS-III, $n = 37$; WMS-III, $n = 35$); Traumatic Brain Injury ($n = 19$). All data are derived from the clinical sample of the following: *Wechsler Adult Intelligence Scale–Third Edition*. Copyright © 1997 by Harcourt Assessment, Inc. Reproduced with permission. All rights reserved. *Wechsler Memory Scale–Third Edition.* Copyright © 1997 by Harcourt Assessment, Inc. Reproduced with permission. All rights reserved.

Discussion

This study developed regression equations using fractional polynomial regression that calculate demographically corrected scores for the standard age-adjusted GAI, DMI, DMI_{alt}, and IMI_{alt} scores using the WAIS-III and WMS-III standardization sample and educational oversample. In order to maintain consistency with previously developed WAIS-III/WMS-III demographic corrections, this study replicated the methodology used in the development of demographically corrected norms made available in the *WAIS-III/WMS-III/WIAT-II Scoring Assistant* (The Psychological Corporation, 2001). The development of demographically corrected norms for these four new indexes enables clinicians to use the GAI, DMI, DMI_{alt}, and IMI_{alt} indexes in conjunction with the traditional WAIS-III and WMS-III index scores, when correcting for the influence of age, education, gender, and ethnicity on test performance.

To illustrate the effect of using demographic versus age corrected norms, consider the following hypothetical case example of two 54-year-old males referred for neuropsychological evaluation for suspected dementia. Patient A was of African American ethnicity that had seven years formal education. Patient B was of Caucasian ethnicity that had 17 years formal education. Both patients obtained the following age-adjusted scores on the four indexes: GAI = 95 (37th percentile), DMI = 77 (6th percentile), DMI_{alt} = 75 (5th percentile), IMI_{alt} = 80 (9th percentile). Based on these scores, a clinician would conclude that both patients have intellectual abilities that fall in the Average range, and immediate and delayed memory abilities that fall in the Borderline to Low Average range. However, when demographic variables other than age are taken into consideration (i.e., ethnicity, education, and gender), Patient A's memory abilities actually fall in the Average range (i.e., *T* scores: GAI = 65, 93rd percentile, DMI = 46, 34th percentile, DMI_{alt} = 44, 27th percentile, IMI_{alt} = 50, 50th percentile), while Patient B's intellectual and memory abilities fall in the Extremely Low range (*T* scores: GAI = 31, 3rd percentile, DMI = 31, 3rd percentile, DMI_{alt} = 30, 2nd percentile, IMI_{alt} = 33, 4th percentile). For both patients, despite similar performances on the WAIS-III and WMS-III, two different conclusions would be drawn when demographical variables, other than just age, are taken into consideration.

Not unexpectedly, education was the most influential demographic variable on all four new age-corrected WAIS-III and WMS-III indexes. This finding is consistent with past research demonstrating education to be a significant variable affecting performance on the revised and third edition Wechsler adult intelligence and memory scales (e.g., Heaton, 1992; Heaton, Taylor, & Manly, 2003; Kaufman, McLean, & Reynolds, 1988; Matarazzo & Herman, 1984; Ryan, Paolo, & Findley, 1991; Reynolds, Chastain, Kaufman, & McLean, 1987). Also consistent with past research demonstrating the influence of demographic variables other than age and education on WAIS/WMS performance (e.g., Shores & Carstairs, 2000; Kaufman, McLean, & Reynolds, 1988; Reynolds, Chastain, Kaufman, & McLean, 1987), ethnicity was also found to substantially influence performance on the four WAIS-III/WMS-III index scores.

In the clinical sample, the sensitivity of the four demographically corrected index scores varied depending on the index score and the diagnostic group under consideration. In the combined clinical group, the GAI was the least sensitive measure and the three memory indexes were the most sensitive. However, this finding is not unexpected given that (a) memory abilities tend to be more susceptible to neurological insult compared to intellectual abilities, and (b) the GAI tends to be less susceptible to neurological insult compared to traditional measures of intellectual ability (e.g., FSIQ; Iverson et al., 2006). For the memory indexes, patients with Korsakoff's syndrome, Alzheimer's, dementia, and Huntington's disease had the highest sensitivity values, while patients with Parkinson's disease, schizophrenia, and traumatic brain injury had the lowest sensitivity values. For a more comprehensive discussion regarding the sensitivity of demographically corrected WAIS-III and WMS-III indexes in this clinical sample, the interested reader is directed to Taylor and Heaton (2001) and Heaton et al. (2003).

Despite the importance of demographically corrected scores, a number of issues should be noted that potentially limits the clinical usefulness of these equations. First, the number of years of education in the equations was restricted to a minimum of 7 years and a maximum of 17 years. When using these equations for individuals whose education levels do not fall in this range, these equations will tend to slightly underestimate index scores for individuals with less than 7 years education, and overestimate index scores in individuals with greater than 17 years of education. Although this problem is not considered substantial, clinicians must remain cautious when using these equations with such individuals. Second, the current analysis did not use individuals of ages 16–19 because their level of formal education was based on their parents' education. Demographically adjusted scores for individuals younger than 20 years of age is not recommended. Third, some concerns have been raised regarding the development of regression-based demographic corrections when some levels of the demographic variables (e.g., very low education) are not adequately represented in the sample (Fastenau & Adams, 1996). Attempts were made to reduce this concern by using the largest and most diverse data available (i.e., inclusion of the education oversample) and by employing a method of choosing optimal fractional polynomials for prediction. However, it is acknowledged that certain groups in the sample were less represented than others (e.g., older, ethnic minorities) and some caution may be warranted when using regression-based demographic corrections for those individuals. However, the approach used here employed the largest and most diverse sample available for the WAIS-III/WMS-III, and demographic corrections based on these data are likely to be more effective than if not taking into account important demographic influences.

References

Axelrod, B. N., & Goldman, R. S. (1996). Use of demographic corrections in neuropsychological interpretation: How standard are standard scores? *The Clinical Neuropsychologist, 10,* 159–162.

Chiaravalloti, N. D., Tulsky, D. S., & Glosser, G. (2004). Cross-validation of the WMS-III Facial memory test with the Graduate Hospital Facial Memory Test in a sample of right and left anterior lobectomy patients. *Journal of Clinical and Experimental Neuropsychology, 24,* 484–497.

Donders, J., Tulsky, D. S., & Zhu, J. (2001). Criterion validity of new WAIS-III subtest scores after traumatic brain injury. *Journal of the International Neuropsychological Society, 7,* 892–898.

Fastenau, P. S., & Adams, K. (1996). Heaton, Grant, and Matthews' comprehensive norms: An overzealous attempt. *Journal of Clinical and Experimental Neuropsychology, 18,* 444–448.

Fisher, D. C., Ledbetter, M. F., Cohen, N. J., Marmor, D., & Tulsky, D. S. (2000). WAIS-III and WMS-III profiles of mildly to severely brain-injured patients. *Applied Neuropsychology, 7,* 126–132.

Hawkins, K. (1998). Indicators of brain dysfunction derived from graphic representations of WAIS-III/WMS-III technical manual clinical samples data. *The Clinical Neuropsychologist, 12,* 535–551.

Heaton, R. K. (1992). *Comprehensive norms for an expanded Halstead-Reitan Battery: A Suppl. for the Wechsler Adult Intelligence Scale-Revised.* Odessa, FL: Psychological Assessment Resources.

Heaton, R. K., Grant, I., & Matthews, C. G. (1991). *Comprehensive norms for an expanded Halstead-Reitan Battery: Demographic corrections, research findings, and clinical applications.* Odessa, FL: Psychological Assessment Resources.

Heaton, R. K., & Marcotte, T. D. (2000). Clinical and neuropsychological tests and assessment techniques. In F. Boller, J. Grafman, & G. Rizzolatti (Eds.). *Handbook of Neuropsychology.* Amsterdam: Elsevier Science.

Heaton, R. K., Miller, S. W., Taylor, J. T., & Grant, I. (2004). *Comprehensive norms for an expanded Halstead-Reitan Battery: Demographically adjusted neuropsychological norms for African American and Caucasian adults, Revised ed.* Lutz, FL: Psychological Assessment Resources.

Heaton, R. K., Ryan, L., Grant, I., & Matthews, C. G. (1996). Demographic influences on neuropsychological test performance. In I. Grant, & K. Adams (Eds.). *Neuropsychological assessment of neuropsychiatric disorders, 2nd ed.* (pp. 141–163). London: Oxford University Press.

Heaton, R. K., Taylor, M. J., & Manly, J. (2003). Demographic effects and use of demographically corrected norms with the WAIS-III and WMS-III. In D. S. Tulsky et al. (Eds.). *Clinical Interpretation of the WAIS-III and WMS-III.* (pp. 181–210). San Diego: Academic Press.

Iverson, G. L., Lange, R. T., Viljeon, H., & Brink, J. (2006). Validation of the WAIS-III General Ability Index in neuropsychiatry and forensic psychiatry inpatient samples. *Archives of Clinical Neuropsychology, 21*(1), 77–82.

Ivnik, R. J., Malec, J. F., Smith, G. E., Tangalos, E. G., Petersen, R. C., Kokmen, E., & Kurland, L. T. (1992). Mayo's Older Americans Normative Studies: WAIS-R norms for ages 56–97. *The Clinical Neuropsychologist, 6 (Suppl.),* 1–30.

Kaufman, A. S., McLean, J. E., & Reynolds, C. R. (1988). Sex, race, residence, region, and education differences on the 11 WAIS-R subtests. *Journal of Clinical Psychology, 44,* 231–248.

Lezak, M. D. (1995). *Neuropsychological Assessment–Third Edition.* New York: Oxford.

Malec, J. F., Ivnik, R. J., Smith, G. E., Tangalos, E. G., Petersen, R. C., Kokmen, E., & Kurland, L. T. (1992). Mayo's Older American Normative Studies: Utility of corrections for age and education for the WAIS-R. *The Clinical Neuropsychologist, 6 (Suppl.*), 31–47.

Martin, T. A., Donders, J., & Thompson, E. (2000). Potential of and problems with new measures of psychometric intelligence after traumatic brain injury. *Rehabilitation Psychology, 45,* 402–408.

Matarazzo, J. D., & Herman, D. O. (1984). Relationship of education and IQ in the WAIS-R standardization sample. *Journal of Consulting and Clinical Psychology, 52,* 631–640.

Millis, S. R., Bowers, D., Malina, A., & Ricker, J. H. (1999). Confirmatory factor analysis of the Wechsler Memory Scale–III. *Journal of Clinical and Experimental Neuropsychology, 21,* 87–93.

Mitrushina, M. N., Boone, K. B., & D'Elia, L. F. (1998). *Handbook of normative data for neuropsychological assessment.* New York: Oxford.

Price, L. R., Tulsky, D. S., Millis, S. R., & Weiss, L. (2002). Redefining the factor structure of the Wechsler Memory Scale-III: Confirmatory factor analysis with cross-validation. *Journal of Clinical and Experimental Neuropsychology, 24,* 574–585.

Reynolds, C. R., Chastain, R. L., Kaufman, A. S., & McLean, J. E. (1987). Demographic characteristics and IQ among adults: Analysis of the WAIS-R standardization sample as a function of the stratification variables. *Journal of School Psychology, 25,* 323–342.

Royston, P., & Altman, D. G. (1994). Regression using fractional polynomials of continuous covariates: Parsimonious parametric modeling. *Applied Statistics, 43,* 429–467.

Ryan, J. J., Paolo, A. M., & Findley, P. G. (1991). Percentile rank conversion tables for WAIS-R IQs at six educational levels. *Journal of Clinical Psychology, 47,* 104–107.

Shores, E. A., & Carstairs, J. R. (2000). The Macquarie University Neuropsychological Normative study (MUNNS): Australian norms for the WAIS-R and WMS-R. *Australian Psychologist, 35,* 41–59.

Spreen, O., & Strauss, E. (1998). *A compendium of neuropsychological tests: Administration, norms, and commentary, 2nd ed.* New York: Oxford.

Taylor, M. J., & Heaton, R. K. (2001). Sensitivity and specificity of WAIS-III/WMS-III demographically corrected factors scores in neuropsychological assessment. *Journal of the International Neuropsychological Society, 7,* 867–874.

The Psychological Corporation. (1997). *WAIS-III/WMS-III Technical Manual.* San Antonio, TX: Author.

The Psychological Corporation. (2001). *WAIS-III/WMS-III/WIAT-II Scoring Assistant.* San Antonio, TX: Author.

Tulsky, D. S., Chelune, G. J., & Price, L. R. (2004). Development of a new delayed memory index for the WMS-III. *Journal of Clinical and Experimental Neuropsychology, 26,* 563–576.

Tulsky, D. S., Chiaravalloti, N. D., Palmer, B., & Chelune, G. J. (2003). The Wechsler Memory Scale–Third Edition: A New Perspective. In

D. S. Tulsky et al (Eds.). *Clinical Interpretation of the WAIS-III and WMS-III.* (pp. 93–139). San Diego: Academic Press.

Tulsky, D. S., Ivnik, R. J., Price, L. R., & Wilkins, C. (2003). Assessment of cognitive functioning with the WAIS-III and WMS-III. Development of a 6-factor model. In D. S. Tulsky et al. (Eds.). *Clinical Interpretation of the WAIS-III and WMS-III.* (pp. 147–179). San Diego: Academic Press.

Tulsky, D. S., Saklofske, D. H., Wilkins, C., & Weiss, L. G. (2001). Development of a General Ability Index for the Wechsler Adult Intelligence Scale–Third Edition. *Psychological Assessment, 13,* 566–571.

Vanderploeg, R. D., Axelrod, B. N., Sherer, M., Scott, J. G., & Adams, R. L. (1997). The importance of demographic adjustments on neuropsychological test performance. A response to Reitan and Wolfson (1995). *The Clinical Neuropsychologist, 11,* 210–217.

Wechsler, D. (1981). *Wechsler Adult Intelligence Scale-Revised.* New York: The Psychological Corporation.

Wechsler, D. (1987). *Wechsler Memory Scale-Revised.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1997a). *Wechsler Adult Intelligence Scale–Third Edition.* San Antonio, TX: The Psychological Corporation.

Wechsler, D. (1997b). *Wechsler Memory Scale–Third Edition.* San Antonio, TX: The Psychological Corporation.

Wilde, N. J., Strauss, E., Chelune, G. J., Hermann, B. P., Hunter, M., Loring, D. W., Martin, R. C., & Sherman, E. M. S. (2003). Confirmatory factor analysis of the WMS-III in patients with temporal lobe epilepsy. *Psychological Assessment, 15,* 56–63.

Yeudall, L. T., Reddon, J. R., Gill, D. M., & Stefanyk, W. O. (1987). Normative data for the Halstead-Reitan neuropsychological tests stratified by age and sex. *Journal of Clinical Psychology, 43,* 346–367.

Received March 3, 2005
Revision received November 16, 2005
Accepted December 12, 2005 ■