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NORMS FOR LETTER AND CATEGORY FLUENCY: DEMOGRAPHIC CORRECTIONS FOR AGE, EDUCATION, AND ETHNICITY

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Letter and category fluency tasks are used to assess semantic knowledge, retrieval ability, and executive functioning. They appear to be useful in detecting different types of dementia, but accurate detection of neuropsychological impairment relies on appropriate normative data. Multiple regression analysis was used to develop demographically corrected norms for letter and category fluency in 768 normal adults. *T*-score equations were developed on a base subsample of 403, and crossvalidated on a separate subsample (n = 365). Participants ranged in age from 20 years to 101 years; in educational level from 0 to 20 years; 55% were Caucasian and 45% were African American. Together, age, education, and ethnicity were significant predictors of letter and category fluency performance, accounting for 15% and 25% of variance, respectively. Formulas and tables for converting raw fluency scores to demographically corrected *T* scores are presented.

Keywords: verbal fluency, normative data, African American, neuropsychological tests, word fluency

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Measures of verbal fluency are widely used in neuropsychological assessment, and have been shown to be especially sensitive to disorders involving the frontal lobes (Janowsky, Shimamura, Kritchevsky, & Squire, 1989; Lezak, 1995). Verbal productivity may be affected by brain damage, even when no other symptoms of aphasia are present. Research examining the correspondence between lesion localization and fluency performance has found that, in general, left frontal lesions are associated with poorer letter fluency (reviewed in Stuss et al., 1998). Fewer studies have examined lesions associated with impaired category fluency, but it appears that the same lesion

sites may impair category fluency, perhaps to an even greater extent (Stuss et al.).

A number of studies have reported that discrepancies between letter and category fluency performance may be useful for early detection of dementia and for distinguishing between cortical and subcortical dementia patients (Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Martin & Fedio, 1983; Troster, Salmon, McCullough, & Butters, 1989). For example, Monsch and colleagues (1994) examined letter (FAS) and category (animals, fruits, vegetables) fluency performance in Alzheimer's disease (AD) patients, Huntington's disease (HD) patients, and two groups of age-matched control adults. The authors found that AD patients showed relatively greater impairment on category than on letter fluency, while HD patients did equally poorly on both tasks. Other studies (Suhr & Jones, 1998), however, have not replicated this finding of differential impairment on letter and category fluency tasks. Conflicting study results may be due in part to differences in patients' dementia severity, diagnostic accuracy, and small sample sizes. Better normative data may be useful for resolving study differences.

Spreen and Strauss (1997) reviewed the normative studies for most versions of verbal fluency. The most commonly used letter fluency stimuli are the letters "F," "A," and "S," whereas "animals" is the most common category cue. Although one study reported that results of "FAS" fluency are comparable to those of "CFL" (Lacy et al., 1996), most researchers advise against using norms for alternate versions of the task because of differences in word frequency associated with each letter (Ruff, Light, Parker, & Levin, 1996; Spreen & Strauss, 1997). Oral, rather than written, versions of the tasks are most often used. Previous studies have shown that demographic variables, including age, education, and gender, are related to performance on verbal fluency tasks (Benton, Hamsher, & Sivan, 1983; Ivnik, Malec, Smith, Tangalos, & Petersen, 1996; Wertz, 1979). The findings, however, are mixed. Most recent normative studies have examined the influence of demographic variables, but the samples vary widely in their diversity and representativeness. The following is a review of the larger normative studies (with at least 100 participants) for oral FAS and Animal fluency tasks.

Yeudall and colleagues (1986) presented FAS normative data from a sample of 225 Canadian participants. Their participants were relatively young, ranging in age from 15 to 40 years (mean age = 24.7 years), and well educated (mean educational level was 14.9 years for men and 14.2 years for women). Both age and education were found to be significantly correlated with FAS performance (correlations = .19 and .32, respectively), but gender was not. Normative data were presented in age by gender groupings.

Bolla and colleagues (1990) examined the effects of age, gender, education, and WAIS-R Vocabulary performance on FAS performance in a sample of 199 healthy "elderly" Caucasian adults who were participants in the Johns Hopkins Teaching Nursing Home Study of Normal Aging. Participants ranged in age from 40 to 89 years (mean age = 64 years), and were relatively well-educated (mean education = 14.7 years; range 8-22 years). More than half of the participants were female (59%). The relative contributions of the demographic variables were analyzed using stepwise regression. Vocabulary (R^2 = .08) and gender (R^2 = .02) made statistically significant contributions to FAS performance, but age and education did not. The use of Vocabulary as a "demographic" variable is a shortcoming of this study, as it probably preempted the evaluation of the education–fluency relationship. Vocabulary is typically considered a "hold" ability, but using it as a demographic variable is problematic in some brain-damaged populations.

Kozora and Cullum (1995) examined the effect of age on fluency performance in 174 healthy adults aged 50 to 90 years. The sample was divided into four age groups that did not differ significantly in terms of mean education or vocabulary performance. Age and education means were presented by age bins. Category fluency, but not letter fluency, differed significantly by age, with the oldest participants producing the fewest number of responses (Pearson r between age and category performance was –.55). Female participants generated significantly fewer animal names than male

participants did, but this may have been due to their lower mean educational level. The authors did not examine the relationship between education and fluency performance.

As a comparison to individuals diagnosed with dementia, Crossley, D'Arcy, and Rawson (1997) presented normative data for both FAS and Animal fluency collected in the Canadian Study of Health and Aging. Of the 635 community dwelling "senior" participants, almost half had fewer than 10 years of education and 59% were female. Age was described as ranging from 65 to "85+ years"; at least 23% were over age 85 years. Means and standard deviations for age and education were not reported for the normal control sample. Effects of demographic variables were analyzed via age group by gender by education group ANOVAs; percentage of variance explained by each variable was not reported. For letter fluency, significant effects were shown for both education and gender, while both education and age had significant effects on animal fluency performance. Normative data for both tasks were presented in separate age, education, and gender groupings.

Tombaugh, Kozak, and Rees (1997) presented the largest normative study of FAS and animal fluency, with 1,300 Canadian participants, ranging in age from 16 to 95 years and in education from 0 to 21 years. Using regression analyses, the authors found that FAS was more sensitive to the effects of education, with 19% of variance explained, than age (11% of variance). In contrast, age accounted for a greater percentage of variance in animal fluency performance than education (23% and 14% of variance, respectively). Gender was not a significant predictor for either task. Normative data were presented in stratified age by education groupings, and by percentile levels.

Taken together, most normative studies have found that increasing age is associated with poorer performance, especially on category fluency tasks. In addition, higher levels of education are associated with better performance on both letter and category fluency. The influence of gender is inconsistently seen on letter fluency, and appears to have no significant effect on category fluency. None of the above mentioned studies reported the ethnic composition of their participant sample.

To our knowledge, only one previous study has examined the influence of ethnicity on letter and category fluency (Johnson-Selfridge, Zalewski, & Aboudarham, 1998). Performance on letter (FAS) and category (Animal) fluency was presented for a sample of 600 male veterans, aged 31 to 46 years (mean age = 37.9 years). The sample was composed of three groups of self-identified Caucasian, African American, and Hispanic participants (n = 200 per ethnic group). Information regarding primary language for the Hispanic participants was not reported. The three groups differed significantly on education, income, and oral reading performance. Results of a multivariate analysis of variance found a significant main effect for ethnicity on both letter and animal fluency tasks, even after covarying education, income, and Wide Range Achievement Test–Revised Reading score. (The variance explained by the covariates was not reported.) Caucasian participants performed better than African American or Hispanic participants on each task. African American participants generated slightly (but significantly) more words than Hispanic participants in the letter fluency condition, although both groups performed similarly on animal fluency. Some shortcomings of the participant selection procedure limit generalizability. First, all participants were male veterans, so the potential effect of gender could not be examined in this sample. Second, the age range of the sample was restricted; all participants were between the ages of 31 and 46 years, and thus, the influence of age on fluency performance was not examined.

A final normative study which examined animal fluency (but not FAS) as part of the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) battery included only elderly African American individuals (Unverzagt et al., 1996). Consequently, the authors were not able to examine the effects of ethnicity. Nonetheless, the study provides useful normative data for participants with similar demographics. The 83 participants ranged in age from 65 to "90+" years (mean age = 74.6 years), and education varied from 0 to "17+" years, with a mean of 10 years. Results of stepwise

multiple regression analysis revealed that education explained 29% of variance in category fluency performance, but age and gender were not significant predicators.

These normative studies demonstrate the importance of correcting for demographic variables, generally considered, when evaluating neuropsychological test performance. However, while important ethnicity effects were demonstrated in the recent Johnson-Selfridge et al. study (1998), no available norms adequately address ethnicity and other demographic variables simultaneously. Also, evidence exists that application of norms developed on predominantly White samples may result in diagnosis of elevated rates of impairment among African Americans (e.g., Roberts & Hamsher, 1984). The Ethical Principles of the American Psychological Association direct psychologists to "attempt to identify situations in which particular...assessment techniques or norms may not be applicable or may require adjustment in administration or interpretation because of factors such as individual's gender, age, race, ethnicity, national origin, religion, sexual orientation, disability, language, or socioeconomic status" (American Psychological Association, 1992).

The goals of the present project were to investigate the influence of all available demographic variables on verbal fluency performance, and to provide tables and formulas for computing demographically-corrected *T* scores for letter and category fluency. One difficult issue complicating the development of appropriate norms is how to define the confounded terms of "race" and "ethnicity." For the sake of convenience, we are using the term "ethnicity," although strictly speaking, we did not assess ethnicity (e.g., we did not assess cultural identification). Most previous research has used the terms "race" and "ethnicity" interchangeably (and somewhat incorrectly). The term "race," however, could imply biological differences that may not, in fact, exist. It is important to note that ethnicity encompasses cultural, language, attitudinal, and experiential differences that are learned or environmental (Evans, Miller, Byrd, & Heaton, 1998). "Race" is often used as a surrogate for ethnicity because the latter is a multifactorial phenomenon about which we have only limited information on our participants. Thus, while differences in neuropsychological functioning between African American and Caucasian participants could well be due to various correlates of race (e.g., socioeconomic status, early nutrition, access to health care, parental ability to provide optimal educational experiences, acculturation factors) rather than race per se, we do not have adequate information on the former factors. In order to assess the generalizability of our norms, we attempted to apply our demographic corrections to summary data from previously published normative studies. Finally, we examined the base rate of letter-category fluency discrepancies, in order to determine how large the difference must be to be statistically significant.

Method

Participants

The normative sample consisted of 768 adult volunteers who were enrolled as normal comparison participants in ongoing research studies of various neurological and psychiatric disorders at the University of California, San Diego, Geriatric Psychiatry Clinical Research Center, Alzheimer's Disease Research Center, or HIV Neurobehavioral Research Center, or who were participants in a federally funded study to develop neuropsychological norms for African American adults (the African American Norms Project, AANP). Most Caucasian participants were recruited through local media announcements and personal contacts. In the case of the AANP, recruiting, via multiplicity sampling, was done to match census track representation of African Americans within the larger San Diego area. In order to determine that all participants were free of conditions that may cause or be associated with cognitive deficits, participants were screened for current and past psychiatric disorders with either the *Structured Clinical Interview for DSM-III-R* (Spitzer, Williams, Gibbon, & First, 1988), or at a minimum, participants denied a past history of having been diagnosed or treated for an Axis I disorder during the clinical interview. Exclusion criteria included any history of significant head trauma (loss of consciousness for greater than 20 minutes or persisting

neurologic sequelae), neurological illness or conditions expected to affect neuropsychological test performance (e.g., developmental disability), any psychotic disorder or other major psychiatric illness, current substance dependence or abuse (within the last 6 months), or primary language other than English. All participants provided written informed consent. Some individuals were paid for their participation.

Ethnic composition of the combined normative sample was 55% Caucasian (n = 422) and 45% African American (n = 346). Participants ranged in age from 20 to 101 years (M = 50.4 years, SD = 19.4 years); 52% were male. Mean educational level for the entire sample was 13.6 years (SD = 3.1 years; range = 0 to 20 years). Education was based on actual number of years of formal academic education successfully completed (vocational training and General Education diplomas were not counted).

Education and age distributions between our African American and Caucasian groups were different because of sampling differences between the various studies from which these normal controls were drawn. Caucasian participants were significantly older (M = 59.0 years, SD = 19.6 years, range = 20 to 101 years) than African American participants (M = 39.2 years, SD = 12.6 years, range = 20 to 73 years; $p < .001$). The Caucasian group also had a higher mean level of education (M = 14.5 years, SD = 2.8 years; range = 2 to 20 years) than the African American group (M = 13.4 years, SD = 2.5 years, range = 8 to 20 years; $p < .005$). Although the modal level of education was 12 years for both groups, 21.0% of the African American group had less than a high school diploma, while only 7.5% of the Caucasian group had not completed high school.

Procedure

All participants completed oral letter and category fluency tasks as part of a larger neuropsychological battery that included the Wechsler Adult Intelligence Scale–Revised (WAIS-R; Wechsler, 1981). The test battery, which lasted 4 to 8 hours depending on the research protocol, was administered in a standardized manner by experienced psychometrists.

For the letter fluency task, participants were asked to name all of the words that they could think of beginning with the letters "F," "A," and "S." Sixty seconds were allowed for each letter. Participants were instructed that proper names (e.g., names of people or places) and plurals were not allowed. Perseverative responses, intrusions (e.g., words beginning with a letter other than the target letter), and close variations of the same word (e.g., "sit" and "sitting") were not counted. The total numbers of "F," "A," and "S" responses were combined for a total score. For the category fluency task, participants generated as many names of animals that they could in 60 seconds. For verbatim instructions, see Appendix A.

Analyses

Demographically corrected T scores for the letter and category fluency tasks were developed according to the general method described in the Heaton, Grant, and Matthews norms book (1991). The following steps were used to convert raw scores to T scores: (a) Each test score distribution was normalized by converting raw scores to scaled scores having a mean of 10 and a standard deviation of 3; (b) the participant sample was split into Base (n = 415) and Validation (n = 353) subsamples, using a pseudorandom selection procedure;[1] (c) using the Base subsample only, hierarchical stepwise multiple regressions were performed using demographic variables to predict scaled scores (variables considered included age, age squared, age cubed, education, education squared, education cubed, gender, ethnicity, and the interaction terms); (d) predicted scaled scores (calculated from the formula based on the regression analysis) for each participant were subtracted from the participant's actual scaled scores to calculate residual scores; and (e) the residual scores were converted to T scores according to the formula: T score = {[(residual score divided by the standard error of estimate for the regression equation) X 10] + 50}.

[1]The participant sample was randomly split into Base and Validation subsamples. Because of sampling characteristics of the various studies from which the participants were derived, older African Americans were under-represented. In order to develop the most generalizable T-score formulae, after the random split, we moved all African American participants over age 50 into the Base subsample.

Because clinically significant changes in performance related to age are not seen during early adulthood, using the actual age of the younger participants would attenuate the linear relationship between age and test scores. Therefore, as in previous norm projects, the ages for participants between 20 and 34 years were coded as 34 years.

Hierarchical stepwise multiple regression in the Base subsample was used to determine which demographic variables improved prediction of letter and category fluency scaled scores. In the first stage, age, education, ethnicity, and gender were evaluated for entry into the regression equation in a stepwise fashion; in the second stage, the higher order variables (squared and cubed) and the interaction terms were considered.

After the *T*-score conversions were derived from data in the Base subsample, they were then applied to the data from the Validation subsample. In order to determine whether demographic influences were removed, bivariate correlations were calculated between subsample *T* scores and the demographic variables (age, education, and ethnicity). In order to determine whether the *T*-score conversions were performing equivalently at all levels of the demographic variables, participants were split into three age groups (20-34, 35-49, 50 years and older) and three educational levels (0-11, 12-15, and 16 years or more). Analyses of variance were used to screen for significant age, education, gender, and ethnicity main effects, and interaction effects, which would indicate that the demographic corrections made were not sufficient or were not equivalent between groups. Variance in fluency *T* scores explained by demographic variables was examined, in order to ensure that these variables explained little or no variance. The Kolmogorov-Smirnoff procedure was used to assess whether the *T*-score distributions differed significantly from normality. Finally, the distributions of predicted and obtained *T* scores were evaluated, using a one standard deviation clinical impairment cutoff score.

Application of computed *T* scores to previous normative studies

The derived *T*-score conversions were applied to data from previously published studies in order to assess the generalizability of the demographic corrections. Because we did not have access to the original data from other studies, we calculated a mean *T* score for each group, using the demographic information and mean raw fluency scores provided for each participant subgroup. For studies in which mean age or education was not provided, the midpoint of the variable range was used in the *T*-score formulas. When information about the ethnic composition of the sample was not available, participants were scored as if they were Caucasian.

Need for and accuracy of ethnicity corrections

In order to further examine the accuracy of the demographically corrected *T*-score formulas, the specificity rates in the African American subsample were examined with and without race corrections. A standard $T < 40$ cutoff score (one standard deviation below the normative mean) was used because this cutoff score generally has been found to maximize sensitivity and specificity in discriminating between normal and brain-damaged participants (Heaton, Grant, & Matthews, 1991).

Results

Base and Validation Subsamples and Fluency Raw Scores

Table 1 summarizes the demographic variables and raw fluency scores for the Base and Validation samples. Twenty-six participants were not administered the animal category fluency task; demographic variables and letter fluency scores did not differ significantly between the subgroups with and without animal fluency data. The Base and Validation subsamples did not differ on age, education, gender, or ethnic composition. There were also no differences on fluency performance between the Base and Validation subsamples.

In the combined sample, there were significant effects of age, education, and ethnicity on fluency performance. Table 2 summarizes FAS and animal

Table 1
Demographic Characteristics and Fluency Scores for the Base and Validation Subsamples

	Base[a]		Validation[b]	
	M	*SD*	*M*	*SD*
Age (years)	52.12	17.22	51.66	17.28
Education (years)	14.09	2.68	13.91	2.67
Male	53%		53%	
Caucasian	53%		56%	
FAS fluency score	40.34	12.60	40.00	11.92
Animal fluency score	19.54	5.39	19.44	5.74

Note. No statistically significant ($p < .05$) group differences were found by independent samples *t* test or chi-square test.
[a]$n = 415$. [b]$n = 353$.

Table 2
Letter and Category Fluency Scores of the Total Sample by Age and Education

	Education range											
	0 - 11 years[a]				12 - 15 years[b]				16+ years[c]			
	FAS		Animal		FAS		Animal		FAS		Animal	
Age range (years)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
20 - 34	38.21	13.43	17.74	5.52	40.30	9.59	21.11	5.90	44.38	10.54	22.88	4.73
35 - 49	33.32	11.93	18.36	6.63	40.63	11.43	19.82	6.26	47.27	13.33	22.28	5.57
50+	31.47	13.21	15.28	3.80	38.63	11.98	18.05	4.81	41.81	12.75	19.35	4.42

[a]$n = 103$. [b]$n = 415$. [c]$n = 250$.

fluency raw scores by age and education ranges. For FAS fluency, a 3 x 3 (age group x education group) analysis of variance (ANOVA) revealed a significant main effect of education, $F(2, 765) = 30.80$, $p < .001$, and a significant age by education interaction $F(4, 759) = 3.20$, $p = .013$. The effect of age alone was not significant, $F(2, 763) = 2.17$, $p = .12$. For animal fluency, the age by education ANOVA revealed significant main effects of education, $F(2, 737) = 25.91$, $p < .001$ and age $F(2, 739) = 16.79$, $p < .001$), but the interaction of age by education was not significant. $F(4, 733) = 1.06$, $p = .38$).

Table 3 shows the fluency raw scores by ethnicity and age. For FAS fluency, a 2 x 3 (race x age group) ANOVA revealed significant main effects of ethnicity, $F(1, 766) = 45.07$, $p < .001$ and age $F(2, 764) = 8.40$, $p < .001$, but the age by ethnicity interaction was not significant. For animal fluency, ethnicity by age group ANOVA revealed significant main effects of ethnicity, $F(1, 740) = 64.15$, $p < .001$ and age $F(2, 738) = 35.00$, $p < .001$, and a significant interaction $F(2, 736) = 3.70$, $p = .025$.

Development of the Prediction Equation and Cross-Validation

The raw score to scaled score conversions are presented in Table 4. Table 5 presents the unstandardized partial regression coefficients (*B*) and intercept, the standardized regression coefficients (β), and R, R^2, and adjusted R^2 (which corrects for goodness of fit of the model in the population) after entry of each of the predictors of fluency

Table 3
Letter and Category Fluency Scores for African American and Caucasian Participants by Age

	African Americans[a]				Caucasians[b]			
	FAS		Animal		FAS		Animal	
Age range (years)	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
20 - 34	38.94	10.49	19.44	5.17	45.37	9.45	24.79	5.20
35 - 49	38.61	12.57	19.11	6.16	47.00	11.81	22.96	5.64
50+	33.87	12.96	16.68	4.71	40.32	12.39	18.59	4.63

[a] $n = 346$. [b] $n = 422$.

Table 4
Scaled Score Equivalents to Raw Scores for Letter (FAS) and Category (Animal) Fluency

	Raw score	
Scaled score	FAS	Animal
19	78+	37+
18	73 - 77	33 - 36
17	67 - 72	31 - 32
16	63 - 66	30
15	58 - 62	29
14	54 - 57	27 - 28
13	50 - 53	25 - 26
12	46 - 49	23 - 24
11	42 - 45	21 - 22
10	37 - 41	19 - 20
9	33 - 36	17 - 18
8	29 - 32	15 - 16
7	26 - 28	14
6	21 - 25	13
5	18 - 20	12
4	15 - 17	11
3	13 - 14	10
2	0 - 12	8 - 9
1		0 - 7

Table 5
Stepwise Regression of Demographic Variables on Letter and Category Fluency Performance

Variables	*B*	β	sr^2 (incremental)
		Letter fluency	
Education	0.255	.234	.073
Age	-0.049	-.266	.024
Race	-1.526	-.254	.048
	Intercept = 9.822		$R^2 = .146$
			Adjusted $R^2 = .140$
			$R = .382$
		Category fluency	
Education	0.294	.238	.075
Age	-0.084	-.432	.070
Race	-2.382	-.368	.102
	Intercept = 11.115		$R^2 = .248$
			Adjusted $R^2 = .242$
			$R = .498$

Note: *B* = partial regression coefficient, β = standardized regression coefficient, sr^2 = squared part correlation coefficient or R^2 change, adjusted R^2 = corrected R^2 for goodness of fit of the model in the population.

scaled scores. R for the regression of letter fluency was significantly different from zero, $F(3, 441) = 25.07$, $p < .0001$. Altogether, education, age, and ethnicity accounted for 14.6% (14.0% adjusted) of the variability in FAS letter fluency performance. For animal category fluency, R for the regression also was highly significant, $F(3, 400) = 43.88$, $p < .0001$). The three demographic variables of education, age, and ethnicity together accounted for 24.8% (24.2% adjusted) of the variance in category fluency. Gender was not a significant predictor for either letter or category fluency performance. Higher order variables (that would reflect nonlinear relationships between demographics and fluency performance) and the interaction terms also were not significant predictors of fluency performance after the basic demographic variables were considered. The prediction equations are presented in Appendix B.

Application of the T-score formulas to the Validation subsample demonstrated the generalizability of the derived equations. As expected, the mean T scores for FAS and animal did not differ significantly from 50 (mean T scores = 50.8 and 51.0, respectively). Table 6 shows the frequency distributions of the fluency scores based on the predicted and actual T scores. Actual fluency score distributions were not significantly different from predictions based on assumptions of a normal distribution (Kolmogorov-Smirnov $p > .05$).

Validation of the Prediction Equation

In order to further test whether the influence of demographic variables had been removed for each fluency measure, two 3 (age group) x 3 (education group) x 2 (race) x 2 (gender) ANOVAs with T scores as the dependent variable were conducted; one of these was with the Validation subsample and the other with the total sample. There were no significant main or interaction effects, indicating that the T-scores conversions were functioning equivalently at all levels of age, education, race, and gender.

Table 6
Predicted and Actual Percentages of FAS and Animal Fluency Scores by T Score

	T-score range						
	0 - 24	25 - 34	35 - 44	45 - 54	55 - 64	65 - 74	75+
Predicted %	0.5	5.5	22.9	38.2	25.4	6.7	0.7
Actual %							
FAS fluency	0.3	6.1	22.0	43.4	21.6	5.2	1.4
Animal fluency	0.3	6.3	20.9	41.5	24.7	4.9	1.4

Table 7
Percentage of Variance Explained by Demographics in Fluency Scaled and T Scores in the Base and Validation Subsamples, and the Total Sample

	Base subsample		Validation subsample		Total sample	
Fluency task	Scaled	T	Scaled	T	Scaled	T
FAS	14.6	0.0	12.2	2.0	13.5	0.4
Animal	24.8	0.0	15.9	0.8	21.4	0.3

Table 8
False Positive Error Rates for African American Participants Without and With Ethnicity Corrections

	False positive error rates	
Fluency task	Without ethnicity correction	With ethnicity correction
FAS	31.2%	15.3%
Animal	38.5%	17.4%

Table 7 presents the demographic influences (R^2 from regression analyses) on the raw fluency scores versus the demographically corrected *T* scores for the Base and Validation subsamples, and the total sample. The *T*-score conversions eliminate or substantially reduce the influence of demographic biases.

In another check on the accuracy of the demographically corrected *T*-score formulas, we compared the specificity rates in the African American group, with and without ethnicity corrections (i.e., treating them as if they were Caucasian). We used the standard 15% false positive error rate cutoff score ($T < 40$) to maximize sensitivity and specificity. Results are presented in Table 8. Correcting for ethnicity decreased the false positive error rate to acceptable levels.

Appendix C presents the demographically corrected norms for FAS and Animal fluency. To use these norms with an individual's test results, first convert the raw fluency score to a scaled score, using Table 4. Then, turn to the part of the Appendix C that corresponds to the individual's race and educational level. Select the appropriate age group column from the top row of the table. Read across the row that corresponds to the individual's scaled score (in the left-most column) to the appropriate age group. That entry indicates the individual's *T* score for the fluency measure.

Application of Computed *T* Scores to Previous Normative Samples

Table 9 presents the estimated mean *T* scores for each of the previously reviewed normative studies (Bolla et al., 1990; Crossley et al., 1997; Johnson-Selfridge et al., 1998; Kozora & Cullum, 1995; Tombaugh et al., 1997; Unverzagt et al., 1996; Yeudall et al., 1986). Since means for age and education were not presented in every study, we estimated the mean to be the midpoint of each range provided. The results were generally consistent with expectations, with most mean *T* scores falling within the clinically normal range (*T* scores of 45 or more) and reasonably close to the expected *T* score of 50. The two exceptions (Crossley et al. study and the Johnson-Selfridge study) will be discussed later.

Differences in Letter and Category Performance Level

Table 10 illustrates the frequency of letter-category fluency *T*-score discrepancies of different magnitudes. Relatively large differences between letter (L) and category (C) fluency performance were not uncommon; 10% of the total sample either had a L > C *T*-score difference of 18 or more, or had a L < C *T*-score difference of 19 or greater. Letter-category fluency discrepancy score was not significantly related to participant's age, education, gender, or ethnicity (all *r*s were less than 0.08).

Discussion

The influence of demographic variables on letter and category fluency performance was examined in a Base subsample of 403 Caucasian and African American adults. Multiple regression analyses revealed that education, age, and ethnicity accounted for a significant proportion of variance in both types of verbal fluency performance. Similar to the results of most previous normative studies, gender did not significantly influence fluency performance. Education and ethnicity explained the largest proportions of variance in letter (FAS) fluency performance, while age, education, and ethnicity were all significant predictors of category (Animal) fluency. Higher education

Table 9
Application of Fluency T-Score Formulas to Previously Published Normative Data

Study	Calculated mean *T* score FAS	Animal
Yeudall et al. (1986)		
Age group 21 - 25 years	45	
26 - 30 years	45	
31 - 40 years	49	
Bolla et al. (1990)[a]		
Males by vocabulary group		
< 53 words	50	
54 - 60 words	53	
> 61 words	54	
Females by vocabulary group		
< 53 words	53	
54 - 60 words	56	
> 61 words	58	
Kozora & Cullum (1995)		
Age group 50 - 59 years	47	51
60 - 69 years	56	54
70 - 79 years	58	54
80 - 89 years	52	48
Johnson-Selfridge et al. (1998)		
White	40	45
Black	47	45
Tombaugh et al. (1997)[b]		
Age group 16 - 59 years		
education 0 - 8 years	50	
9 - 12 years	48	46
13 - 21 years	45	47
Age group 60 - 79 years		
education 0 - 8 years	45	52
9 - 12 years	50	52
13 - 21 years	47	49
Age group 60 - 79 years		
education 0 - 8 years	48	54
9 - 12 years	49	51
13 - 21 years	47	47
Unverzagt et al. (1996)		56

(continued)

Table 9 (continued)
Application of Fluency T-Score Formulas to Previously Published Normative Data

Study	Calculated mean *T* score FAS	Animal
Crossley et al. (1997)[c]		
Age group 65 - 74 years	41	48
75 - 84 years	47	51
85+ years	45	50
Education group 0 - 6 years	39	48
7 - 9 years	43	47
10 - 12 years	44	48
13+ years	47	46

[a]Grouped by WAIS-R Vocabulary raw score. [b]Used fluency raw score for 50th percentile score. [c]Used overall mean educational level = 8.8 years, and overall mean age = 79.8 years.

Table 10
Frequency of Letter-Category T-Score Discrepancies

Difference between Letter (L) & Category (C) fluency *T* scores	% L > C	% L < C
30 +	0.5	0.4
26-29	0.7	0.4
22-25	1.4	1.9
19-21	1.9	2.0
16-18	3.1	2.2
13-15	4.1	4.5
10-12	5.7	6.7
7-9	7.1	8.5
4-6	10.0	13.5
1-3	10.8	11.8
0	2.6	2.6

and Caucasian ethnicity were associated with better performance on both fluency tasks, while older age was associated with poorer performance. No significant nonlinear effects or interaction effects of age and education were found, after linear effects were considered in the regression analyses.

The *T*-score equations derived on the Base subsample were successfully applied to the Validation subsample (n = 365). Results of correlational analyses and ANOVAs demonstrated that the *T*-score conversions removed all or most demographic biases from both the Base and Validation subsamples. The derived *T*-score formulas simultaneously correct for all relevant demographic variables, and thus obviate the need for the clinician to weight and combine the effects of each variable (Goldberg, 1970).

Application of the *T*-score conversions to previously published normative data also tends to support the generalizability of these demographically corrected equations. Our assessment of generalizability was necessarily approximate because many previous studies failed to provide detailed data about the mean age and education of their samples; thus, *T*-score conversions were based on the less optimal midpoints of reported ranges. Furthermore, our definition of educational achievement, which counts actual years of education completed, is probably different and more stringent than the criterion used in many other studies (which may count a General Education Diploma as equivalent to 12 years of education). Nevertheless, despite large age, educational, ethnic, regional, and national differences among the samples, most groups had *T*-scores reasonably close to 50. The two notable exceptions were the White participants in the Johnson-Selfridge et al. (1998) study, and some of subgroups from the Crossley et al. (1997) study that included elderly Canadian adults. The lower than expected *T*-scores in the Johnson-Selfridge study may be due to highly selected nature of the sample; all participants were Vietnam-era veterans, and had a relatively low mean income level. Lower socioeconomic status may be associated with poorer medical care and environmental conditions that can have negative impacts on the development and maintenance of neurocognitive abilities (Anastasi, 1988). It is also possible that the applied education correction was overly harsh if the authors counted a GED earned in the military as 12 years of education.

A possible explanation for the low *T* scores in some of the Crossley et al. (1997) subgroups is the fact that some individuals reportedly were fluent in French or were bilingual (although the proportion of individuals was not reported, and results from English and French speaking individuals were presented together). It is clear from the results of this and other studies (cf., Kaufman, McLean, & Reynolds, 1988) that cultural and language differences can have significant impacts on test performance. For example, word frequencies associated with each letter of the alphabet varies among different languages. This raises an important limitation of the present study. The demographically corrected *T*-scores presented here should be used only with persons for whom English is their first language. Additional norms are needed for bilingual individuals.

Specificity of the demographic corrections was demonstrated by examining the false positive error rate in the African American participants. Treating these participants as Caucasian resulted in an inflated false positive error rate for African American individuals (more than twice the acceptable rate), and confirmed the expectation that use of normative data developed on a Caucasian sample may not be appropriate for non-Caucasian individuals. Despite the limitations of treating race as a surrogate for ethnicity, the results demonstrated that corrections for race can minimize the misdiagnoses of impairment in African American individuals.

Previous studies have found that discrepancies in letter and category fluency performance may be useful in distinguishing between elderly normal persons and individuals in the early stages of Alzheimer's disease (Monsch, Bondi, Butters, Salmon, Katzman, & Thal, 1992). In particular, patients with Alzheimer's disease do relatively worse on category tasks than letter fluency tasks. The letter-category fluency *T*-score discrepancy data presented here may prove useful for developing a clinically meaningful cutoff score to detect early cortical dementia.

The present study fills an important gap in normative studies on verbal fluency. The sample was large, and included a large proportion of African American participants. The results were cross-validated on separate subsample, and were shown to be generalizable to data collected in seven other diverse normative studies (combined n = 3,216). The derived T-score conversion equations allow simultaneous consideration of age, education, and ethnicity, in order to provide the most representative normative comparison data. A future need is to develop appropriate demographic corrections for other ethnic groups.

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Appendix A

Instructions for Letter (FAS) and Category (Animals) Fluency Tasks

Verbatim Instructions for the Controlled Oral Word Association Test (FAS)

"I am going to say a letter of the alphabet to you, and I want you to tell me as many words as you can think of that begin with that letter. But none of the words can be proper names of people or places. For instance, if I gave you the letter "B," you could say "brook, bottle, black," and so forth, but you could not say "Barbara" since that is a person's name, nor could you say "Boston," since that is the proper name of a place. Also, do not give me the same word with different endings, such as sit, sits, and sitting."

"The first letter we will use is "F." Go ahead and tell me as many words as you can think of that begin with "F."

(Begin timing. Record all responses verbatim. Do not interrupt the respondent or ask him or her to slow down. It is permissible to repeat instructions if the respondent loses set or forgets what he or she is supposed to be doing. Stop the respondent after 60 seconds. "A" and "S" trial are introduced in the same manner as above.)

Verbatim Instructions for Category Fluency

"Now we are going to do something a little different. This time I want you to tell me all of the animal names that you can think of. It doesn't matter what letter they start with. Just tell me all of the animal names that you can think of."

(Record the animal names in the same manner as above.)

Appendix B

Letter (FAS) and Category (Animal) Norms Formulas

Demographically corrected *T* scores for fluency can be calculated as follows:

Letter (FAS) *T* score = 14.796 + (3.584 x FAS Scaled Score) – (0.914 x Education) + (0.177 x Age) + (5.470 x Race)

Category (Animal) *T* score = 10.450 + (3.558 x Animal Scaled Score) – (1.048 x Education) + (0.301 x Age) + (8.476 x Race)

Education = years of education successfully completed.

Age = actual age (if age is 20-34 years, age is coded as 34 years).

Race: Caucasian = 0, African American = 1.

Appendix C

T-Score Equivalents for Letter and Category Fluency by Age, Education, and Ethnicity

Appendix C

Table C1

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 8 or Fewer Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	82	80	82	81	83	82	84	84	85	85	86	87	87	88	87	90	88	91	89	93	90	94	91	96	92	97
18	78	76	79	77	79	79	80	80	81	82	82	83	83	85	84	86	85	88	86	89	87	91	87	92	88	93
17	74	73	75	74	76	75	77	77	78	78	79	80	79	81	80	83	81	84	82	86	83	87	84	89	84	90
16	71	69	71	70	72	72	73	73	74	75	75	76	76	78	77	79	78	81	78	82	79	84	80	85	81	86
15	67	66	68	67	69	68	70	70	70	71	71	73	72	74	73	76	74	77	75	79	76	80	77	82	77	83
14	64	62	64	63	65	65	66	66	67	68	68	69	69	71	70	72	70	74	71	75	72	77	73	78	74	79
13	60	59	61	59	62	61	62	62	63	64	64	65	65	67	66	68	67	70	68	72	69	73	69	75	70	75
12	57	55	57	56	58	57	59	59	60	60	61	62	61	63	62	65	63	66	64	68	65	69	66	71	66	72
11	53	51	53	52	54	54	55	55	56	57	57	58	58	60	59	61	60	63	61	64	61	66	62	67	63	68
10	49	48	50	49	51	50	52	52	53	53	53	55	54	56	55	58	56	59	57	61	58	62	59	64	59	65
9	46	44	46	45	47	47	48	48	49	50	50	51	51	53	52	54	52	56	53	57	54	59	55	60	56	61
8	42	41	43	42	44	43	44	45	45	46	46	48	47	49	48	51	49	52	50	54	51	55	52	57	52	58
7	39	37	39	38	40	40	41	41	42	43	43	44	44	46	44	47	45	49	46	50	47	52	48	53	49	54
6	35	34	36	35	36	36	37	38	38	39	39	41	40	42	41	44	42	45	43	47	44	48	44	50	45	51
5	31	30	32	31	33	32	34	34	35	36	36	37	36	39	37	40	38	42	39	43	40	45	41	46	41	47
4	28	27	28	27	29	29	30	30	31	32	32	33	33	35	34	36	35	38	35	39	36	41	37	42	38	43
3	24	23	25	24	26	25	27	27	27	28	28	30	29	31	30	33	31	34	32	36	33	37	34	39	34	40
2	21	19	21	20	22	22	23	23	24	25	25	26	26	28	27	29	27	31	28	32	29	34	30	35	31	36
1		16		17		18		20		21		23		24		26		27		29		30		32		33

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C2

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 9 to 11 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	80	78	80	79	81	80	82	82	83	83	84	85	85	86	86	88	87	89	87	91	88	92	89	94	90	95
18	76	74	77	75	78	77	78	78	79	80	80	81	81	83	82	84	83	86	84	87	85	89	86	90	86	91
17	73	71	73	72	74	73	75	75	76	76	77	78	78	79	78	81	79	82	80	84	81	85	82	87	83	88
16	69	67	70	68	70	70	71	71	72	73	73	74	74	76	75	77	76	79	77	80	78	82	78	83	79	84
15	65	64	66	64	67	66	68	67	69	69	70	71	70	72	71	74	72	75	73	77	74	78	75	80	75	80
14	62	60	62	61	63	62	64	64	65	65	66	67	67	68	68	70	69	71	69	73	70	74	71	76	72	77
13	58	56	59	57	60	59	61	60	61	62	62	63	63	65	64	66	65	68	66	69	67	71	68	72	68	73
12	55	53	55	54	56	55	57	57	58	58	59	60	60	61	61	63	61	64	62	66	63	67	64	69	65	70
11	51	49	52	50	53	52	53	53	54	55	55	56	56	58	57	59	58	61	59	62	60	64	60	65	61	66
10	48	46	48	47	49	48	50	50	51	51	52	53	52	54	53	56	54	57	55	59	56	60	57	62	57	63
9	44	42	44	43	45	45	46	46	47	48	48	49	49	51	50	52	51	54	52	55	52	57	53	58	54	59
8	40	39	41	40	42	41	43	43	44	44	44	46	45	47	46	49	47	50	48	52	49	53	50	55	50	56
7	37	35	37	36	38	38	39	39	40	41	41	42	42	44	43	45	43	47	44	48	45	50	46	51	47	52
6	33	32	34	32	35	34	35	35	36	37	37	38	38	40	39	41	40	43	41	44	42	46	43	48	43	48
5	30	28	30	29	31	30	32	32	33	33	34	35	35	36	35	38	36	39	37	41	38	42	39	44	40	45
4	26	24	27	25	27	27	28	28	29	30	30	31	31	33	32	34	33	36	34	37	35	39	35	40	36	41
3	22	21	23	22	24	23	25	25	26	26	27	28	27	29	28	31	29	32	30	34	31	35	32	37	32	38
2	19	17	19	18	20	20	21	21	22	23	23	24	24	26	25	27	26	29	26	30	27	32	28	33	29	34
1		14		15		16		18		19		21		22		24		25		27		28		30		31

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C3

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 12 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	78	76	78	77	79	78	80	80	81	81	82	83	83	84	84	86	85	87	86	89	86	90	87	92	88	93
18	74	72	75	73	76	75	77	76	78	78	78	79	79	81	80	82	81	84	82	85	83	87	84	88	84	89
17	71	69	71	70	72	71	73	73	74	74	75	76	76	77	77	79	78	80	78	82	79	83	80	85	81	85
16	67	65	68	66	69	67	70	69	70	70	71	72	72	73	73	75	74	76	75	78	76	79	77	81	77	82
15	64	61	64	62	65	64	66	65	67	67	68	68	69	70	69	71	70	73	71	74	72	76	73	77	74	78
14	60	58	61	59	61	60	62	62	63	63	64	65	65	66	66	68	67	69	68	71	69	72	69	74	70	75
13	56	54	57	55	58	57	59	58	60	60	61	61	61	63	62	64	63	66	64	67	65	69	66	70	66	71
12	53	51	53	52	54	53	55	55	56	56	57	58	58	59	59	61	60	62	60	64	61	65	62	67	63	68
11	49	47	50	48	51	50	52	51	52	53	53	54	54	56	55	57	56	59	57	60	58	62	59	63	59	64
10	46	44	46	45	47	46	48	48	49	49	50	51	51	52	52	54	52	55	53	57	54	58	55	60	56	61
9	42	40	43	41	44	43	44	44	45	46	46	47	47	49	48	50	49	52	50	53	51	55	51	56	52	57
8	39	37	39	37	40	39	41	40	42	42	43	43	43	45	44	47	45	48	46	50	47	51	48	53	48	53
7	35	33	35	34	36	35	37	37	38	38	39	40	40	41	41	43	42	44	43	46	43	47	44	49	45	50
6	31	29	32	30	33	32	34	33	35	35	35	36	36	38	37	39	38	41	39	42	40	44	41	45	41	46
5	28	26	28	27	29	28	30	30	31	31	32	33	33	34	34	36	35	37	35	39	36	40	37	42	38	43
4	24	22	25	23	26	25	26	26	27	28	28	29	29	31	30	32	31	34	32	35	33	37	34	38	34	39
3	21	19	21	20	22	21	23	23	24	24	25	26	26	27	26	29	27	30	28	32	29	33	30	35	31	36
2	17	15	18	16	18	18	19	19	20	21	21	22	22	24	23	25	24	27	25	28	26	30	26	31	27	32
1		12		13		14		16		17		19		20		22		23		25		26		28		29

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C4

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 13 to 15 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	76	74	77	75	78	76	78	78	79	79	80	81	81	82	82	84	83	85	84	87	85	88	86	90	86	90
18	73	70	73	71	74	72	75	74	76	75	77	77	77	78	78	80	79	81	80	83	81	85	82	86	82	87
17	69	67	69	67	70	69	71	70	72	72	73	73	74	75	75	76	76	78	77	79	77	81	78	82	79	83
16	65	63	66	64	67	65	68	67	69	68	69	70	70	71	71	73	72	74	73	76	74	77	75	79	75	80
15	62	59	62	60	63	62	64	63	65	65	66	66	67	68	68	69	69	71	69	72	70	74	71	75	72	76
14	58	56	59	57	60	58	61	60	61	61	62	63	63	64	64	66	65	67	66	69	67	70	68	72	68	73
13	55	52	55	53	56	55	57	56	58	58	59	59	60	61	60	62	61	64	62	65	63	67	64	68	65	69
12	51	49	52	50	52	51	53	53	54	54	55	56	56	57	57	59	58	60	59	62	60	63	60	65	61	66
11	47	45	48	46	49	48	50	49	51	51	52	52	52	54	53	55	54	57	55	58	56	60	57	61	57	62
10	44	42	44	42	45	44	46	46	47	47	48	49	49	50	50	52	51	53	51	55	52	56	53	58	54	58
9	40	38	41	39	42	40	43	42	43	43	44	45	45	46	46	48	47	49	48	51	49	52	50	54	50	55
8	37	34	37	35	38	37	39	38	40	40	41	41	42	43	43	44	43	46	44	47	45	49	46	50	47	51
7	33	31	34	32	35	33	35	35	36	36	37	38	38	39	39	41	40	42	41	44	42	45	42	47	43	48
6	30	27	30	28	31	30	32	31	33	33	34	34	34	36	35	37	36	39	37	40	38	42	39	43	39	44
5	26	24	26	25	27	26	28	28	29	29	30	31	31	32	32	34	33	35	34	37	34	38	35	40	36	41
4	22	20	23	21	24	23	25	24	26	26	26	27	27	29	28	30	29	32	30	33	31	35	32	36	32	37
3	19	17	19	18	20	19	21	21	22	22	23	24	24	25	25	27	26	28	26	30	27	31	28	33	29	34
2	15	13	16	14	17	16	17	17	18	19	19	20	20	22	21	23	22	25	23	26	24	28	25	29	25	30
1		10		10		12		13		15		16		18		20		21		23		24		26		26

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C5

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 16 to 17 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	74	71	74	72	75	73	76	75	77	76	78	78	79	79	80	81	81	82	81	84	82	85	83	87	84	88
18	70	67	71	68	72	70	73	71	73	73	74	74	75	76	76	77	77	79	78	80	79	82	80	83	80	84
17	67	64	67	65	68	66	69	68	70	69	71	71	72	72	73	74	73	75	74	77	75	78	76	80	77	81
16	63	60	64	61	65	63	65	64	66	66	67	67	68	69	69	70	70	72	71	73	72	75	72	76	73	77
15	60	57	60	58	61	59	62	61	63	62	64	64	64	65	65	67	66	68	67	70	68	71	69	73	69	74
14	56	53	56	54	57	56	58	57	59	59	60	60	61	62	62	63	63	65	64	66	64	68	65	69	66	70
13	52	50	53	51	54	52	55	54	56	55	56	57	57	58	58	60	59	61	60	63	61	64	62	66	62	67
12	49	46	49	47	50	49	51	50	52	52	53	53	54	55	55	56	55	58	56	59	57	61	58	62	59	63
11	45	43	46	43	47	45	47	46	48	48	49	49	50	51	51	52	52	54	53	55	54	57	55	58	55	59
10	42	39	42	40	43	41	44	43	45	44	46	46	47	47	47	49	48	50	49	52	50	53	51	55	51	56
9	38	35	39	36	39	38	40	39	41	41	42	42	43	44	44	45	45	47	46	48	46	50	47	51	48	52
8	34	32	35	33	36	34	37	36	38	37	38	39	39	40	40	42	41	43	42	45	43	46	44	48	44	49
7	31	28	31	29	32	31	33	32	34	34	35	35	36	37	37	38	38	40	38	41	39	43	40	44	41	45
6	27	25	28	26	29	27	30	29	30	30	31	32	32	33	33	35	34	36	35	38	36	39	37	41	37	42
5	24	21	24	22	25	24	26	25	27	27	28	28	29	30	30	31	30	33	31	34	32	36	33	37	34	38
4	20	18	21	19	21	20	22	22	23	23	24	25	25	26	26	28	27	29	28	31	29	32	29	34	30	34
3	16	14	17	15	18	16	19	18	20	19	21	21	21	22	22	24	23	26	24	27	25	29	26	30	26	31
2	13	11	13	11	14	13	15	14	16	16	17	17	18	19	19	20	20	22	21	23	21	25	22	26	23	27
1		7		8		9		11		12		14		15		17		18		20		21		23		24

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C6

T-Score Equivalents for FAS and Animal Fluency Tasks for Caucasians With 18 or More Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	72	69	73	70	73	71	74	73	75	74	76	76	77	77	78	79	79	80	80	82	81	83	81	85	82	86
18	68	65	69	66	70	68	71	69	72	71	73	72	73	74	74	75	75	77	76	78	77	80	78	81	78	82
17	65	62	65	63	66	64	67	66	68	67	69	69	70	70	71	72	72	73	72	75	73	76	74	78	75	79
16	61	58	62	59	63	61	64	62	64	64	65	65	66	67	67	68	68	70	69	71	70	73	71	74	71	75
15	58	55	58	56	59	57	60	59	61	60	62	62	63	63	64	65	64	66	65	68	66	69	67	71	68	72
14	54	51	55	52	56	54	56	55	57	57	58	58	59	60	60	61	61	63	62	64	63	66	63	67	64	68
13	51	48	51	48	52	50	53	51	54	53	55	54	55	56	56	57	57	59	58	60	59	62	60	64	60	64
12	47	44	47	45	48	46	49	48	50	49	51	51	52	52	53	54	54	55	55	57	55	58	56	60	57	61
11	43	40	44	41	45	43	46	44	47	46	47	47	48	49	49	50	50	52	51	53	52	55	53	56	53	57
10	40	37	40	38	41	39	42	41	43	42	44	44	45	45	46	47	46	48	47	50	48	51	49	53	50	54
9	36	33	37	34	38	36	38	37	39	39	40	40	41	42	42	43	43	45	44	46	45	48	46	49	46	50
8	33	30	33	31	34	32	35	34	36	35	37	37	38	38	38	40	39	41	40	43	41	44	42	46	43	47
7	29	26	30	27	30	29	31	30	32	32	33	33	34	35	35	36	36	38	37	39	38	41	38	42	39	43
6	25	23	26	24	27	25	28	27	29	28	29	30	30	31	31	33	32	34	33	36	34	37	35	39	35	40
5	22	19	22	20	23	21	24	23	25	25	26	26	27	28	28	29	29	31	29	32	30	34	31	35	32	36
4	18	16	19	16	20	18	21	19	21	21	22	22	23	24	24	25	25	27	26	28	27	30	28	31	28	32
3	15	12	15	13	16	14	17	16	18	17	19	19	20	20	21	22	21	23	22	25	23	26	24	28	25	29
2	11	8	12	9	12	11	13	12	14	14	15	15	16	17	17	18	18	20	19	21	20	23	20	24	21	25
1		5		6		7		9		10		12		13		15		16		18		19		21		22

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C7

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 8 or Fewer Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	87	88	88	89	88	91	89	92	90	94	91	95	92	97	93	98	94	100	95	101	96	103	96	104	97	105
18	83	85	84	86	85	87	86	89	87	90	88	92	88	93	89	95	90	96	91	98	92	99	93	101	93	102
17	80	81	80	82	81	84	82	85	83	87	84	88	85	90	86	91	87	93	88	94	88	96	89	97	90	98
16	76	78	77	79	78	80	79	82	80	83	80	85	81	86	82	88	83	89	84	91	85	92	86	94	86	95
15	73	74	73	75	74	77	75	78	76	80	77	81	78	83	79	84	79	86	80	87	81	89	82	90	83	91
14	69	71	70	71	71	73	71	75	72	76	73	78	74	79	75	81	76	82	77	84	78	85	79	87	79	87
13	66	67	66	68	67	69	68	71	69	72	70	74	71	75	71	77	72	78	73	80	74	81	75	83	75	84
12	62	63	63	64	63	66	64	67	65	69	66	70	67	72	68	73	69	75	70	76	70	78	71	79	72	80
11	58	60	59	61	60	62	61	64	62	65	62	67	63	68	64	70	65	71	66	73	67	74	68	76	68	77
10	55	56	55	57	56	59	57	60	58	62	59	63	60	65	61	66	62	68	62	69	63	71	64	72	65	73
9	51	53	52	54	53	55	54	57	54	58	55	60	56	61	57	63	58	64	59	66	60	67	61	69	61	70
8	48	49	48	50	49	52	50	53	51	55	52	56	53	58	53	59	54	61	55	62	56	64	57	65	58	66
7	44	46	45	47	45	48	46	50	47	51	48	53	49	54	50	56	51	57	52	59	53	60	53	62	54	63
6	40	42	41	43	42	45	43	46	44	48	45	49	45	51	46	52	47	54	48	55	49	57	50	58	50	59
5	37	39	37	39	38	41	39	42	40	44	41	45	42	47	43	49	44	50	45	52	45	53	46	55	47	55
4	33	35	34	36	35	37	36	39	37	40	37	42	38	43	39	45	40	46	41	48	42	49	43	51	43	52
3	30	31	30	32	31	34	32	35	33	37	34	38	35	40	36	41	36	43	37	44	38	46	39	47	40	48
2	26	28	27	29	28	30	28	32	29	33	30	35	31	36	32	38	33	39	34	41	35	42	36	44	36	45
1		24		25		27		28		30		31		33		34		36		37		39		40		41

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C8

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 9 to 10 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	85	86	86	87	87	89	88	90	88	92	89	93	90	95	91	96	92	98	93	99	94	101	95	102	95	103
18	82	83	82	84	83	85	84	87	85	88	86	90	87	91	88	93	88	94	89	96	90	97	91	99	92	100
17	78	79	79	80	79	82	80	83	81	85	82	86	83	88	84	89	85	91	86	92	87	94	87	95	88	96
16	74	76	75	77	76	78	77	80	78	81	79	83	79	84	80	86	81	87	82	89	83	90	84	92	84	92
15	71	72	71	73	72	74	73	76	74	77	75	79	76	80	77	82	78	83	79	85	79	87	80	88	81	89
14	67	68	68	69	69	71	70	72	71	74	71	75	72	77	73	78	74	80	75	81	76	83	77	84	77	85
13	64	65	64	66	65	67	66	69	67	70	68	72	69	73	70	75	70	76	71	78	72	79	73	81	74	82
12	60	61	61	62	62	64	62	65	63	67	64	68	65	70	66	71	67	73	68	74	69	76	70	77	70	78
11	57	58	57	59	58	60	59	62	60	63	61	65	62	66	62	68	63	69	64	71	65	72	66	74	66	75
10	53	54	54	55	54	57	55	58	56	60	57	61	58	63	59	64	60	66	61	67	61	69	62	70	63	71
9	49	51	50	52	51	53	52	55	53	56	53	58	54	59	55	61	56	62	57	64	58	65	59	67	59	68
8	46	47	46	48	47	50	48	51	49	53	50	54	51	56	52	57	53	59	53	60	54	62	55	63	56	64
7	42	44	43	44	44	46	45	48	45	49	46	51	47	52	48	54	49	55	50	57	51	58	52	60	52	60
6	39	40	39	41	40	42	41	44	42	45	43	47	44	48	44	50	45	51	46	53	47	54	48	56	49	57
5	35	36	36	37	36	39	37	40	38	42	39	43	40	45	41	46	42	48	43	49	44	51	44	52	45	53
4	31	33	32	34	33	35	34	37	35	38	36	40	36	41	37	43	38	44	39	46	40	47	41	49	41	50
3	28	29	28	30	29	32	30	33	31	35	32	36	33	38	34	39	35	41	36	42	36	44	37	45	38	46
2	24	26	25	27	26	28	27	30	28	31	28	33	29	34	30	36	31	37	32	39	33	40	34	42	34	43
1		22		23		25		26		28		29		31		32		34		35		37		38		39

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C9

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 12 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	83	84	84	85	85	87	86	88	87	90	87	91	88	93	89	94	90	96	91	97	92	99	93	100	93	101
18	80	81	80	82	81	83	82	85	83	86	84	88	85	89	86	91	87	92	87	94	88	95	89	97	90	97
17	76	77	77	78	78	79	79	81	79	82	80	84	81	86	82	87	83	89	84	90	85	92	86	93	86	94
16	73	74	73	74	74	76	75	77	76	79	77	80	78	82	79	83	79	85	80	86	81	88	82	89	83	90
15	69	70	70	71	71	72	71	74	72	75	73	77	74	78	75	80	76	81	77	83	78	84	78	86	79	87
14	66	66	66	67	67	69	68	70	69	72	70	73	70	75	71	76	72	78	73	79	74	81	75	82	75	83
13	62	63	62	64	63	65	64	67	65	68	66	70	67	71	68	73	69	74	70	76	70	77	71	79	72	80
12	58	59	59	60	60	62	61	63	62	65	62	66	63	68	64	69	65	71	66	72	67	74	68	75	68	76
11	55	56	55	57	56	58	57	60	58	61	59	63	60	64	61	66	61	67	62	69	63	70	64	72	65	73
10	51	52	52	53	53	55	53	56	54	58	55	59	56	61	57	62	58	64	59	65	60	67	61	68	61	69
9	48	49	48	50	49	51	50	53	51	54	52	56	53	57	53	59	54	60	55	62	56	63	57	65	57	65
8	44	45	45	46	45	47	46	49	47	50	48	52	49	53	50	55	51	56	52	58	52	59	53	61	54	62
7	40	41	41	42	42	44	43	45	44	47	44	48	45	50	46	51	47	53	48	54	49	56	50	57	50	58
6	37	38	37	39	38	40	39	42	40	43	41	45	42	46	43	48	44	49	44	51	45	52	46	54	47	55
5	33	34	34	35	35	37	36	38	36	40	37	41	38	43	39	44	40	46	41	47	42	49	43	50	43	51
4	30	31	30	32	31	33	32	35	33	36	34	38	35	39	36	41	36	42	37	44	38	45	39	47	40	48
3	26	27	27	28	27	30	28	31	29	33	30	34	31	36	32	37	33	39	34	40	35	42	35	43	36	44
2	22	24	23	25	24	26	25	28	26	29	27	31	27	32	28	34	29	35	30	37	31	38	32	40	32	41
1		20		21		23		24		26		27		29		30		32		33		35		36		37

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C10

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 13 to 15 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	82	82	82	83	83	85	84	86	85	88	86	89	87	91	87	92	88	94	89	95	90	97	91	98	92	99
18	78	79	79	79	79	81	80	82	81	84	82	85	83	87	84	88	85	90	86	91	87	93	87	94	88	95
17	74	75	75	76	76	77	77	79	78	80	78	82	79	83	80	85	81	86	82	88	83	89	84	91	84	92
16	71	71	71	72	72	74	73	75	74	77	75	78	76	80	77	81	78	83	78	84	79	86	80	87	81	88
15	67	68	68	69	69	70	70	72	70	73	71	75	72	76	73	78	74	79	75	81	76	82	77	84	77	85
14	64	64	64	65	65	67	66	68	67	70	68	71	69	73	70	74	70	76	71	77	72	79	73	80	74	81
13	60	61	61	62	62	63	62	65	63	66	64	68	65	69	66	71	67	72	68	74	69	75	69	77	70	78
12	57	57	57	58	58	60	59	61	60	63	61	64	61	66	62	67	63	69	64	70	65	72	66	73	66	74
11	53	54	53	55	54	56	55	58	56	59	57	61	58	62	59	64	60	65	61	67	61	68	62	70	63	70
10	49	50	50	51	51	52	52	54	53	55	53	57	54	58	55	60	56	62	57	63	58	65	59	66	59	67
9	46	47	46	47	47	49	48	50	49	52	50	53	51	55	52	56	52	58	53	59	54	61	55	62	56	63
8	42	43	43	44	44	45	44	47	45	48	46	50	47	51	48	53	49	54	50	56	51	57	52	59	52	60
7	39	39	39	40	40	42	41	43	42	45	43	46	44	48	44	49	45	51	46	52	47	54	48	55	48	56
6	35	36	36	37	36	38	37	40	38	41	39	43	40	44	41	46	42	47	43	49	43	50	44	52	45	53
5	31	32	32	33	33	35	34	36	35	38	35	39	36	41	37	42	38	44	39	45	40	47	41	48	41	49
4	28	29	28	30	29	31	30	33	31	34	32	36	33	37	34	39	35	40	35	42	36	43	37	45	38	46
3	24	25	25	26	26	28	27	29	27	31	28	32	29	34	30	35	31	37	32	38	33	40	34	41	34	42
2	21	22	21	23	22	24	23	26	24	27	25	29	26	30	27	32	27	33	28	35	29	36	30	38	31	38
1		18		19		20		22		23		25		26		28		29		31		32		34		35

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C11

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 16 to 17 Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	79	79	80	80	81	82	82	83	82	85	83	86	84	88	85	89	86	91	87	92	88	94	89	95	89	96
18	76	76	76	77	77	78	78	80	79	81	80	83	81	84	82	86	82	87	83	89	84	90	85	92	86	93
17	72	72	73	73	74	75	74	76	75	78	76	79	77	81	78	82	79	84	80	85	81	87	82	88	82	89
16	69	69	69	70	70	71	71	73	72	74	73	76	74	77	74	79	75	80	76	82	77	83	78	85	78	86
15	65	65	66	66	66	68	67	69	68	71	69	72	70	74	71	75	72	77	73	78	73	80	74	81	75	82
14	61	62	62	63	63	64	64	66	65	67	65	69	66	70	67	72	68	73	69	75	70	76	71	78	71	79
13	58	58	58	59	59	61	60	62	61	64	62	65	63	67	64	68	65	70	65	71	66	73	67	74	68	75
12	54	55	55	55	56	57	57	58	57	60	58	61	59	63	60	65	61	66	62	68	63	69	64	71	64	71
11	51	51	51	52	52	53	53	55	54	56	55	58	56	59	56	61	57	62	58	64	59	65	60	67	61	68
10	47	47	48	48	48	50	49	51	50	53	51	54	52	56	53	57	54	59	55	60	56	62	56	63	57	64
9	43	44	44	45	45	46	46	48	47	49	48	51	48	52	49	54	50	55	51	57	52	58	53	60	53	61
8	40	40	40	41	41	43	42	44	43	46	44	47	45	49	46	50	47	52	47	53	48	55	49	56	50	57
7	36	37	37	38	38	39	39	41	39	42	40	44	41	45	42	47	43	48	44	50	45	51	46	53	46	54
6	33	33	33	34	34	36	35	37	36	39	37	40	38	42	39	43	39	45	40	46	41	48	42	49	43	50
5	29	30	30	31	31	32	31	34	32	35	33	37	34	38	35	40	36	41	37	43	38	44	39	46	39	47
4	26	26	26	27	27	29	28	30	29	32	30	33	31	35	31	36	32	38	33	39	34	41	35	42	35	43
3	22	23	22	23	23	25	24	26	25	28	26	29	27	31	28	32	29	34	30	35	30	37	31	38	32	39
2	18	19	19	20	20	21	21	23	22	24	22	26	23	27	24	29	25	30	26	32	27	33	28	35	28	36
1		15		16		18		19		21		22		24		25		27		28		30		31		32

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).

Appendix C

Table C12

T-Score Equivalents for FAS and Animal Fluency Tasks for African Americans With 18 or More Years of Education

Age (years)	20-34		35-39		40-44		45-49		50-54		55-59		60-64		65-69		70-74		75-79		80-84		85-89		90+	
SS	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C	L	C
19	77	77	78	78	79	80	80	81	81	83	82	84	82	86	83	87	84	89	85	90	86	92	87	93	87	94
18	74	74	74	75	75	76	76	78	77	79	78	81	79	82	80	84	81	85	82	87	82	88	83	90	84	91
17	70	70	71	71	72	73	73	74	74	76	74	77	75	79	76	80	77	82	78	83	79	85	80	86	80	87
16	67	67	67	68	68	69	69	71	70	72	71	74	72	75	73	77	73	78	74	80	75	81	76	83	77	84
15	63	63	64	64	65	66	65	67	66	69	67	70	68	72	69	73	70	75	71	76	72	78	73	79	73	80
14	60	60	60	60	61	62	62	64	63	65	64	67	65	68	65	70	66	71	67	73	68	74	69	76	69	76
13	56	56	57	57	57	58	58	60	59	61	60	63	61	64	62	66	63	67	64	69	64	70	65	72	66	73
12	52	52	53	53	54	55	55	56	56	58	56	59	57	61	58	62	59	64	60	65	61	67	62	68	62	69
11	49	49	49	50	50	51	51	53	52	54	53	56	54	57	55	59	56	60	56	62	57	63	58	65	59	66
10	45	45	46	46	47	48	48	49	48	51	49	52	50	54	51	55	52	57	53	58	54	60	55	61	55	62
9	42	42	42	43	43	44	44	46	45	47	46	49	47	50	47	52	48	53	49	55	50	56	51	58	52	59
8	38	38	39	39	39	41	40	42	41	44	42	45	43	47	44	48	45	50	46	51	47	53	47	54	48	55
7	34	35	35	36	36	37	37	39	38	40	39	42	39	43	40	45	41	46	42	48	43	49	44	51	44	52
6	31	31	31	32	32	34	33	35	34	37	35	38	36	40	37	41	38	43	39	44	39	46	40	47	41	48
5	27	28	28	28	29	30	30	31	30	33	31	34	32	36	33	37	34	39	35	41	36	42	37	44	37	44
4	24	24	24	25	25	26	26	28	27	29	28	31	29	32	30	34	30	35	31	37	32	38	33	40	34	41
3	20	20	21	21	22	23	22	24	23	26	24	27	25	29	26	30	27	32	28	33	29	35	30	36	30	37
2	17	17	17	18	18	19	19	21	20	22	21	24	22	25	22	27	23	28	24	30	25	31	26	33	26	34
1		13		14		16		17		19		20		22		23		25		26		28		29		30

Note. L = Letter (FAS) fluency task; C = Category (Animal) fluency task; SS = Scaled Score (see Table 4).