Pergamon

Archives of Clinical Neuropsychology
19 (2004) 203–214

Archives of CLINICAL NEUROPSYCHOLOGY

Trail Making Test A and B: Normative data stratified by age and education

Tom N. Tombaugh*

Psychology Department, Carleton University, 1125 Colonel By Drive, Ottawa, Ont., Canada K1S 5B6

Accepted 2 January 2003

Abstract

Normative data for the Trail Making Test (TMT) A and B are presented for 911 community-dwelling individuals aged 18–89 years. Performance on the TMT decreased with increasing age and lower levels of education. Based on these results, the norms were stratified for both age (11 groups) and education (2 levels). The current norms represent a more comprehensive set of norms than previously available and will increase the ability of neuropsychologists to determine more precisely the degree to which scores on the TMT reflect impaired performance for varying ages and education.

Keywords: Trail Making Test; Normative data; Age and education; Trails

The Trail Making Test (TMT) is one of the most popular neuropsychological tests and is included in most test batteries. The TMT provides information on visual search, scanning, speed of processing, mental flexibility, and executive functions. Originally, it was part of the Army Individual Test Battery (1944) and subsequently was incorporated into the Halstead–Reitan Battery (Reitan & Wolfson, 1985). The TMT consists of two parts. TMT-A requires an individual to draw lines sequentially connecting 25 encircled numbers distributed on a sheet of paper. Task requirements are similar for TMT-B except the person must alternate between numbers and letters (e.g., 1, A, 2, B, 3, C, etc.). The score on each part represents the amount of time required to complete the task.

The TMT is sensitive to a variety of neurological impairments and processes (Lezak, 1995; Mitrushina, Boone, & D'Elia, 1999; Spreen & Strauss, 1998). In spite of the popularity of the TMT, surprising few comprehensive sets of norms exist. Initially, it was proposed that absolute

* Tel.: +1-613-520-2659; fax: +1-613-520-3667.
E-mail address: ttombaug@ccs.carleton.ca (T.N. Tombaugh).

0887-6177/$ – see front matter © 2003 National Academy of Neuropsychology.
doi:10.1016/S0887-6177(03)00039-8

cutoff scores could be used to identify organic impairment (Matarazzo, Wiens, Matarazzo, & Goldstein, 1974; Reitan, 1959; Reitan & Wolfson, 1985). This practice was soon abandoned when research clearly revealed that age, education, and intelligence affected TMT performance (Spreen & Strauss, 1998). Currently, interpretation of TMT scores relies on various normative data sets. However, a survey of the available normative data shows that virtually no norms exist which are stratified over a wide range of age, education, and intelligence. For example, a review of the 24 published normative studies contained in the *Handbook of Normative Data for Neuropsychological Assessment* (Mitrushina et al., 1999) reveals that most TMT norms contained a relatively small number of individuals within a restricted age and educational range. Only two studies presented data from cognitively intact individuals aged 20–69 years (Bornstein, 1985; Stuss, Stethem, & Pelchat, 1988). Two additional studies used ages ranging from 20 to 79 years (Davies, 1986; Heaton, Grant, & Matthews, 1991). Spreen and Strauss (1998) also present unpublished normative data from Tombaugh, Rees, and McIntyre (1998) which contains 267 individuals aged 20–85 years.

Several shortcomings are evident in these studies. For example, Davies (1986) and Tombaugh et al. (1998) lack information on educational level and type of exclusionary criteria employed. Bornstein (1985) and Stuss et al. (1988) present only means and standard deviations. It is difficult to accurately transform these data into percentile or scaled scores, particularly in the absence of information about the normal distribution of scores. Only one study presents T scores or percentile scores that are based on age, education, and gender (Heaton et al., 1991). Data from 486 participants are divided into two gender groups by 10 age groups and by 6 educational groups. However, as cautioned in Spreen and Strauss (1998), cell sizes are not provided and may be quite small making interpretation of scores problematic.

In view of the literature cited above, interpretation of scores from TMT-A and -B is seriously curtailed by the lack of a comprehensive set of norms. The current study attempts to overcome this lack of adequate norms by presenting data from 911 community-dwelling adults that are stratified into 11 age groups (18–89 years) and 2 education levels (0–12 and 12+ years).

1. Method

1.1. Participants and materials

The normative sample consisted of 680 individuals who participated in a series of experiments investigating the effects of age on the acquisition and retention of visual and verbal information (Hubley & Tombaugh, 2002; McIntyre, 1996; Tombaugh, 1996), 143 participants who were involved in a study measuring speed of information processing (Rees & Tombaugh, 2002), and 88 individuals who participated in phases 1 and 2 of the Canadian Study on Health and Aging (CSHA, 1994). All 911 participants were community-dwelling volunteers. In the first four studies, participants were recruited through booths at shopping centers, social organizations, places of employment, psychology classes, and by word-of-mouth. They did not receive any financial remuneration for participating. A self-reported history of medical and psychiatric problems was obtained from each participant. Any person with a history of neurological disease, psychiatric illness, head injury, or stroke was excluded. Participants from

CSHA were a subset of individuals who had received a consensus diagnosis of "no cognitive impairment" on two successive evaluations separated by approximately 5 years. The classification was made by physicians and clinical neuropsychologists on the basis of history, clinical and neurological examination, and an extensive battery of neuropsychological tests including the TMT.

All participants were living independently in the community and ranged in age from 18 to 89 years ($M = 58.5$, S.D. $= 21.7$). The education level varied from 5 to 25 years ($M = 12.6$, S.D. $= 2.6$). The male to female ratio was 408 to 503. All persons scored higher than 23 ($M = 28.6$, S.D. $= 1.5$) on the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975), and lower than 14 ($M = 4.1$, S.D. $= 3.4$) on the Geriatric Depression Scale (GDS; Brink et al., 1982). CSHA participants were excluded on the basis of a clinical evaluation of depression rather than their score on the GDS.

Trails A and B were administered according to the guidelines presented by Spreen and Strauss (1998). In essence, participants were instructed to complete each part of the TMT as quickly and accurately as possible. When an error was made, the participant was instructed to return to the "circle" where the error originated and continue. Time to complete each part was recorded.

2. Results

Correlations among the demographic variables and scores on Trail A and B show that age was more highly correlated with the scores than was education (Table 1). Gender was not significantly correlated with TMT scores. The relative effects of age, education, and gender on Trails A and B scores were further explored by using regression analyses where each variable was entered separately. Age accounted for 34% and 38% of the variance for Trails A and B, while education accounted for only 3% and 6%. Gender accounted for less than 1%. When education was entered hierarchically after age, its effect was further reduced to less than 1% for Trail A and less than 2% for Trail B.

Since performance on Trails A and B was affected by age and education, a finding consistent with other literature (Lezak, 1995; Mitrushina et al., 1999; Spreen & Strauss, 1998), it was decided to stratify the norms by these two variables. The scores were divided into 11 age

Table 1
Correlations of age, education, gender with time (s) to complete Trails A and B

	Age	Education	Gender	Trail A
Age				
Education	−.17**			
Gender	−.08*	−.03		
Trail A	.58**	−.17**	−.05	
Trail B	.62**	−.25**	−.05	.74**

* $p < .05$.
** $p < .01$.

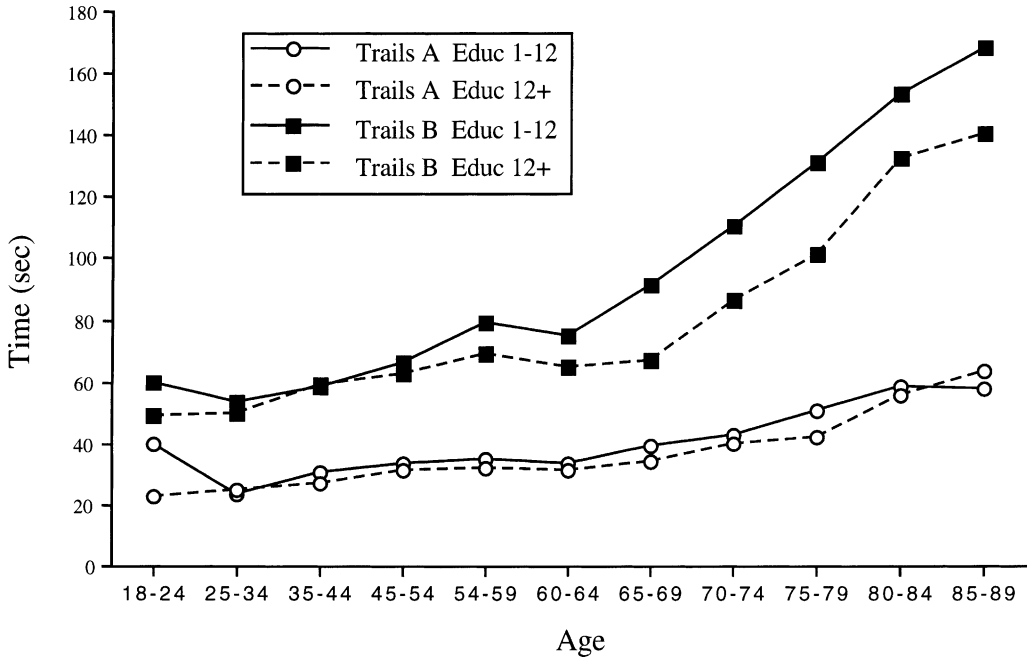

Fig. 1. Performance on Trails A and B as a function of 11 age groups and 2 education levels. Age group 18–24 contained only university students with educational levels of 12+ years.

groups and 2 education levels (see Fig. 1). Analyses of variance appropriate for a 10 (Age) × 2 (Education) factorial design were performed on these data for Trails A and B (age group 18–24 was omitted from the ANOVA because it consisted solely of university students who had 12+ years of education). Scores on Trails A and B increased with increasing age and fewer years of education. The effects of age and education were more pronounced on Trail B than on Trail A (Trail A: Age: $F(9, 736) = 31.73$, $p < .001$; Education: $F(1, 736) = 2.99$, $p > .05$; Age × Education: $F(9, 736) = .81$, $p > .05$; Trail B: Age: $F(9, 736) = 46.25$, $p < .001$; Education: $F(1, 736) = 19.84$, $p < .001$; Age × Education: $F(9, 736) = 1.13$, $p > .05$).

The above analyses suggested that a clinically useful set of norms could be generated by transforming the scores from each Age × Education group into percentile scores. However, a series of regression analyses showed that education accounted for virtually none of the variance in the 25–54 age range (Trails A and B = 0.3% and 1.1%) compared with the 55–89 age range (Trails A and B = 1.5% and 4.4%). The results of these analyses, coupled with the fact that most of the participants in the 25–54 age range were relatively well educated, led to the decision to divide only the older age groups into two education levels (0–12 and 12+ years). Table 2 presents the mean, S.D., median, minimum–maximum value, skewness, and kurtosis for age, education, gender, and scores on Trails A and B for each of the normative groups. Table 3 presents the normative data for Trails A and B transformed into percentile scores using SPSS 8.0.

Table 2
Statistical properties for age, education, gender, Trails A and B (s) for each normative group

	Statistics				
Age groups	Mean (S.D.)	Median	Minimum–maximum	Skewness	Kurtosis
Age group 18–24 ($n = 155$)					
Age	20.17 (1.48)	20.00	18–24		
Education	12.92 (1.01)	13.00	10–15		
Gender	1.59 (0.49)				
Trail A (s)	22.93 (6.87)	21.70	12–57	1.64	4.46
Trail B (s)	48.97 (12.69)	47.00	29–95	.91	.92
Age group 25–34 ($n = 33$)					
Age	29.42 (2.87)	30.00	25–34		
Education	14.18 (1.61)	14.00	11–18		
Gender	1.58 (0.50)				
Trail A (s)	24.40 (8.71)	23.00	10–45	.78	.21
Trail B (s)	50.68 (12.36)	50.00	29–78	.14	−.59
Age group 35–44 ($n = 39$)					
Age	39.74 (2.94)	41.00	35–44		
Education	13.59 (2.06)	14.00	10–20		
Gender	1.59 (0.50)				
Trail A (s)	28.54 (10.09)	26.00	12–50	.64	−.35
Trail B (s)	58.46 (16.41)	58.00	29–95	.59	.01
Age group 45–54 ($n = 41$)					
Age	48.54 (2.96)	48.00	45–54		
Education	13.68 (2.80)	14.00	8–21		
Gender	1.61 (0.49)				
Trail A (s)	31.78 (9.93)	31.00	18–56	.83	.44
Trail B (s)	63.76 (14.42)	64.00	32–92	−.32	−.32
Age group 55–59 ($n = 95$)					
Education 0–12 years ($n = 58$)					
Age	56.90 (1.31)	57.00	55–59		
Education	11.05 (1.05)	11.00	8–12		
Gender	1.55 (0.50)				
Trail A(s)	35.10 (10.94)	32.00	19–72	1.42	2.18
Trail B (s)	78.84 (19.09)	73.50	42–127	.73	.09
Education 12+ years ($n = 37$)					
Age	57.05 (1.45)	57.00	55–59		
Education	15.32 (1.93)	16.00	13–18		
Gender	1.51 (0.51)				
Trail A (s)	31.72 (10.14)	30.00	18–55	1.25	.77
Trail B (s)	68.74 (21.02)	65.00	30–121	.91	1.29
Age group 60–64 ($n = 86$)					
Education 0–12 years ($n = 55$)					
Age	62.33 (1.28)	63.00	60–64		
Education	10.84 (1.27)	11.00	7–12		
Gender	1.56 (0.50)				
Trail A (s)	33.22 (9.10)	33.00	20–49	.04	−1.39
Trail B (s)	74.55 (19.55)	72.00	40–138	1.23	2.14

Table 2(*Continued*)

	Statistics				
Age groups	Mean (S.D.)	Median	Minimum–maximum	Skewness	Kurtosis
Education 12+ years ($n = 31$)					
Age	61.94 (1.50)	62.00	60–64		
Education	15.45 (1.31)	16.00	13–18		
Gender	1.52 (0.51)				
Trail A (s)	31.32 (6.96)	31.00	20–47	.50	−.45
Trail B (s)	64.58 (18.59)	60.00	37–116	1.15	1.68
Age group 65–69 ($n = 97$)					
Education 0–12 years ($n = 65$)					
Age	67.04 (1.63)	67.00	65–69		
Education	10.87 (1.71)	12.00	5–12		
Gender	1.62 (0.49)				
Trail A (s)	39.14 (11.84)	39.00	17–71	.48	.16
Trail B (s)	91.32 (28.89)	86.00	49–190	1.23	2.12
Education 12+ years ($n = 32$)					
Age	67.22 (1.43)	67.00	65–69		
Education	15.91 (1.87)	16.00	13–21		
Gender	1.58 (0.50)				
Trail A (s)	33.84 (6.69)	32.00	23–47	.55	−.67
Trial B (s)	67.12 (9.31)	68.00	48–84	−.41	−.64
Age group 70–74 ($n = 106$)					
Education 0–12 years ($n = 76$)					
Age	71.99 (1.40)	72.00	70–74		
Education	10.50 (1.72)	11.00	6–12		
Gender	1.45 (0.50)				
Trail A (s)	42.47 (15.15)	38.00	20–89	1.47	2.51
Trail B (s)	109.95 (35.15)	101.00	45–190	.59	−.61
Education 12+ years ($n = 30$)					
Age	72.07 (1.60)	72.00	70–74		
Education	15.43 (2.21)	15.00	13–22		
Gender	1.47 (0.51)				
Trail A (s)	40.13 (14.48)	36.00	26–75	1.52	1.49
Trail B (s)	86.27 (24.07)	83.50	55–159	.97	1.26
Age group 75–79 ($n = 108$)					
Education 0–12 years ($n = 74$)					
Age	77.32 (1.35)	78.00	75–79		
Education	10.80 (1.50)	11.50	6–12		
Gender	1.58 (0.50)				
Trail A (s)	50.81 (17.44)	50.00	25–109	1.11	1.56
Trail B (s)	130.61 (45.74)	120.00	57–274	.75	.31
Education 12+ years ($n = 34$)					
Age	77.21 (1.49)	77.00	75–79		
Education	15.29 (1.80)	15.00	13–18		
Gender	1.53 (0.51)				
Trail A (s)	41.74 (15.32)	40.00	19–75	.57	−.27
Trail B (s)	100.68 (44.16)	87.00	53–207	.85	−.21

Table 2(*Continued*)

	Statistics				
Age groups	Mean (S.D.)	Median	Minimum–maximum	Skewness	Kurtosis
Age group 80–84 ($n = 118$)					
Education 0–12 years ($n = 84$)					
Age	81.94 (1.41)	82.00	80–84		
Education	10.48 (1.54)	11.00	7–12		
Gender	1.52 (0.50)				
Trail A (s)	58.19 (23.31)	52.50	25–116	.84	.11
Trail B (s)	152.74 (65.68)	139.50	55–315	.81	−.06
Education 12+ years ($n = 34$)					
Age	81.56 (1.52)	81.00	80–84		
Education	15.50 (2.54)	16.00	13–25		
Gender	1.41 (0.50)				
Trail A (s)	55.32 (21.28)	48.00	29–105	1.30	.91
Trail B (s)	132.15 (42.95)	128.00	67–249	1.42	1.85
Age group 85–89 ($n = 29$)					
Education 0–12 years ($n = 16$)					
Age	86.38 (1.50)	86.00	85–89		
Education	9.88 (1.96)	10.50	6–12		
Gender	1.69 (0.48)				
Trail A (s)	57.56 (21.54)	54.50	36–120	1.75	3.87
Trail B (s)	167.69 (78.50)	142.50	83–366	1.26	1.50
Education 12+ years ($n = 13$)					
Age	86.31 (1.65)	86.00	85–89		
Education	16.23 (2.45)	16.00	13–22		
Gender	1.62 (0.51)				
Trail A (s)	63.46 (29.22)	53.00	35–127	1.60	1.82
Trail B (s)	140.54 (75.38)	121.00	63–308	1.24	.77

Table 3
Percentiles for Trails A and B scores (s) for each normative group

	Education 0–12 years		Education 12+ years		Total	
Percentile	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
Age group 18–24 (university students; $n = 155$)						
90					16	35
80					17	38
70					19	41
60					20	44
50					22	47
40					23	49
30					25	54
20					27	61
10					31	66

Table 3 (*Continued*)

	Education 0–12 years		Education 12+ years		Total	
Percentile	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
Age group 25–34 ($n = 33$)						
90					14	33
80					17	38
70					19	45
60					21	48
50					23	50
40					25	53
30					27	58
20					33	63
10					40	67
Age group 35–44 ($n = 39$)						
90					16	40
80					20	45
70					23	50
60					24	53
50					26	58
40					28	60
30					32	62
20					36	70
10					46	87
Age group 45–54 ($n = 41$)						
90					19	42
80					23	50
70					27	59
60					29	62
50					31	64
40					33	68
30					34	72
20					38	75
10					50	84
Age group 55–59						
	Education 0–12 years ($n = 58$)		Education 12+ years ($n = 37$)		Total ($n = 95$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	25	56	22	42	23	56
80	27	64	24	56	25	58
70	29	66	25	57	27	64
60	31	71	26	61	30	66
50	32	74	30	65	32	73
40	34	81	32	71	33	74
30	38	87	33	74	35	83
20	40	98	37	81	40	90
10	50	105	53	102	53	104

Table 3 (*Continued*)

Age group 60–64

	Education 0–12 years ($n = 55$)		Education 12+ years ($n = 31$)		Total ($n = 86$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	21	56	22	45	22	48
80	24	58	25	48	24	56
70	26	62	26	53	26	59
60	30	67	27	59	29	62
50	33	72	31	60	32	68
40	37	75	33	66	34	72
30	40	79	35	71	37	77
20	43	92	37	77	42	84
10	45	96	43	87	45	96

Age group 65–69

	Education 0–12 years ($n = 65$)		Education 12+ years ($n = 32$)		Total ($n = 97$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	24	60	26	52	25	56
80	30	71	28	57	29	62
70	32	74	30	63	31	70
60	36	81	31	67	32	73
50	39	86	32	68	37	76
40	40	93	34	71	39	83
30	44	103	39	73	42	91
20	47	110	40	75	45	104
10	56	137	45	77	53	121

Age group 70–74

	Education 0–12 years ($n = 76$)		Education 12+ years ($n = 30$)		Total ($n = 106$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	25	70	26	59	26	64
80	30	79	29	63	30	76
70	35	83	31	68	34	81
60	37	95	33	80	36	85
50	38	101	36	84	38	97
40	42	112	41	85	41	105
30	46	124	42	103	45	112
20	52	146	46	109	49	138
10	57	172	71	112	61	159

Table 3 (*Continued*)

Age group 75–79

	Education 0–12 years ($n = 74$)		Education 12+ years ($n = 34$)		Total ($n = 108$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	30	78	22	57	27	65
80	37	92	27	59	34	79
70	39	96	34	66	38	88
60	45	107	37	73	40	98
50	50	120	40	87	46	115
40	53	140	43	105	50	128
30	56	156	46	126	54	148
20	61	167	58	141	58	163
10	72	189	66	178	70	185

Age group 80–84

	Education 0–12 years ($n = 84$)		Education 12+ years ($n = 34$)		Total ($n = 118$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	31	72	37	89	31	84
80	39	101	38	100	39	101
70	43	112	41	111	42	111
60	49	119	46	113	47	116
50	53	140	48	128	52	133
40	59	154	56	131	58	144
30	66	176	58	139	63	159
20	78	204	64	151	75	193
10	90	259	101	227	93	241

Age group 85–89

	Education 0–12 years ($n = 16$)		Education 12+ years ($n = 13$)		Total ($n = 29$)	
	Trail A	Trail B	Trail A	Trail B	Trail A	Trail B
90	37	89	35	70	36	81
80	39	95	42	81	39	87
70	43	112	49	87	47	95
60	47	132	52	90	51	121
50	55	143	53	121	54	138
40	56	188	60	143	56	150
30	63	194	67	156	65	194
20	72	214	78	212	68	199
10	94	317	125	290	120	296

3. Discussion

The major clinical utility of the current study is that it provides a set of norms that will increase the ability of neuropsychologists to determine more precisely the degree to which scores on Trails A and B reflect impaired performance for varying ages and education. The stratification of the norms was based on findings that clearly showed that performance on Trails A and B was affected by age and education, but not by gender. Fig. 1, as well as the accompanying statistical statistical analyses, show that increasing age and decreasing levels of education significantly decreased performance on Trails A and B. As previously mentioned, these results are consistent with those presented in other studies. Since this literature has been amply summarized in several handbooks (Lezak, 1995; Mitrushina et al., 1999; Spreen & Strauss, 1998), it will not be reviewed further.

In using the norms, it should be noted that the influence of age and education is not equivalent on Trails A and B. On Trail A, performance clearly decreased with age but not with education. This suggests that previously published norms which stratified Trail A scores solely on the basis of age are probably appropriate for interpreting performance over a wide range of educational levels. However, this clearly is not the case with Trail B, particularly when age is greater than 54 years. Although the regression analyses show that age accounts for more variance than education, particularly when age is entered first, the normative data show that both age and education should be considered when interpreting clinical scores for older groups.

When evaluating norms for the TMT, Mitrushina et al. (1999) set forth the following seven guidelines: (1) sample size of at least 50 subjects per grouping, (2) description of sample composition including exclusionary criteria, (3–5) presenting data by age, IQ, and education, (6) reporting gender distribution, and (7) presenting means and standard deviations for total time in seconds for TMT-A and -B. The norms from the current study clearly meet five of these criteria (2, 3, 5, 6, and 7). The failure to present IQ scores (Criterion 4) is not judged to be a particularly serious drawback given the completeness of data for education levels and the well known positive association between education and IQ. The second possible shortcoming of the present study is the failure of all normative cells to have at least 50 subjects (Criterion 1). However, this "failure" does not appear to be a particular serious shortcoming since the present study contains more participants than any previously published set of TMT norms and divides many of the age groups into two educational levels. If only the age grouping are considered, then 8 of the 11 age groups have greater than 50 participants. The systematic increase in scores for each education level with increasing age for the participants older than 54 also indicates that an adequate number of participants had been used to ensure representative data. However, some caution should be exercised in interpreting scores from the oldest age group (85–89) because of the restricted sample size. It should also be noted that all members of the youngest group (18–24) were university students.

References

Army Individual Test Battery. (1944). *Manual of Directions and Scoring*. Washington, DC: War Department, Adjutant General's Office.

Bornstein, R. A. (1985). Normative data on selected neuropsychological measures from a nonclinical sample. *Journal of Clinical Psychology*, *42*, 651–659.

Brink, T. L., Lyesavage, T. L., Lum, O., Heersma, P. H., Adey, H., & Rose, T. L. (1982). Screening tests for geriatric depressions. *Clinical Gerontologist*, *1*, 37–44.

Canadian Study of Health and Aging Working Group. (1994). Canadian study of health and aging: Study methods and prevalence of dementia. *Canadian Medical Association Journal*, *150*, 899–913.

Davies, A. (1986). The influence of age on Trail Making Test performance. *Journal of Clinical Psychology*, *24*, 96–98.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). Mini-Mental State: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*, 189–198.

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.

Hubley, A. M., & Tombaugh, T. N. (2002). *Memory Test for Older Adults (MTOA)*. Toronto, Canada: Multi-Health Systems.

Lezak, M. D. (1995). *Neuropsychological assessment* (3rd ed.). New York: Oxford University Press.

Matarazzo, J. D., Wiens, A. N., Matarazzo, R. G., & Goldstein, S. G. (1974). Psychometric and clinical test-retest reliability of the Halstead Impairment Index in a sample of healthy, young, normal men. *Journal of Nervous and Mental Disease*, *158*, 37–49.

McIntyre, N. (1996). *The Recognition Memory Battery: Normative data from age 16 to 85*. Unpublished doctoral dissertation, Carleton University, Ottawa, Ontario.

Mitrushina, M. N., Boone, K. L., & D'Elia, L. (1999). *Handbook of normative data for neuropsychological assessment*. New York: Oxford University Press.

Rees, L., & Tombaugh, T. N. (2002). *The Computerized Test of Information Processing (CTIP)*. Unpublished test from Carleton University, Ottawa, Ontario.

Reitan, R. M. (1959). *Manual for administration of neuropsychological test batteries for adults and children*. Unpublished manuscript.

Reitan, R. M., & Wolfson, D. (1985). *The Halstead–Reitan Neuropsycholgical Test Battery: Therapy and clinical interpretation*. Tucson, AZ: Neuropsychological Press.

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

Stuss, D. T., Stethem, L. L., & Pelchat, G. (1988). Three tests of attention and rapid information processing. An extension. *The Clinical Neuropsychologist*, *2*, 246–250.

Tombaugh, T. N. (1996). *The Test of Memory Malingering (TOMM)*. Toronto, Canada: Multi-Health Systems.

Tombaugh, T. N., Rees, L., & McIntyre, N. (1998). Normative data for the Trail Making Test. Personal communication cited in Spreen and Strauss. *A compendium of neuropsychological tests: Administration, norms and commentary* (2nd ed.). New York: Oxford University Press.