Archives of Clinical Neuropsychology 21 (2006) 23–28

Normative Symbol Digit Modalities Test performance in a community-based sample

Laura K. Sheridan [a,*], Hiram E. Fitzgerald [a], Kenneth M. Adams [b,c], Joel T. Nigg [a], Michelle M. Martel [a], Leon I. Puttler [b], Maria M. Wong [b], Robert A. Zucker [b]

[a] *Department of Psychology, Michigan State University, East Lansing, MI 48823, USA*
[b] *Department of Psychiatry and Addiction Research Center, University of Michigan, Ann Arbor, MI, USA*
[c] *VA Ann Arbor Healthcare System, Ann Arbor, MI, USA*

Accepted 17 July 2005

Abstract

The Symbol Digit Modalities Test [SDMT; Smith, A. (1982). *Symbol Digit Modalities Test*. Los Angeles: Western Psychological Services; Smith, A. (1968). The symbol-digit modalities test: a neuropsychologic test of learning and other cerebral disorders. In J. Helmuth (Ed.), *Learning disorders* (pp. 83–91). Seattle: Special Child Publications] is a substitution task that is the inverse of the Digit Symbol Test [Wechsler, D. (1955). *Manual for the Wechsler Adult Intelligence Scale (WAIS)*. New York: The Psychological Corporation]. The familiar task of filling numbers in boxes, and the availability of an oral administration, make this a popular screening instrument for brain impairment. Normative data were previously reported for a variety of clinical groups, but complete information on non-clinical samples across age, education, gender, and socioeconomic status is limited. The present study examines the performance of a community-dwelling control sample across age, education, gender, and income groupings. In a multivariate model, these four variables did not impact test performance. These results support the utilization of the SDMT as a robust screening test for adult neuropsychological impairment.

Keywords: Neuropsychological assessment; Normative sample; Cognitive ability

The Symbol Digit Modalities Test (SDMT; Smith, 1968, 1982) was developed to identify individuals with neurological impairment. An altered, inverse form of the Digit Symbol Test (Wechsler, 1955), the SDMT assesses key neurocognitive functions that underlie many substitution tasks, including attention, visual scanning, and motor speed. The brevity and ease of administration, and its unambiguous scoring, contribute to its widespread use. Correlations of the SDMT with the Digit Symbol Test, test-retest correlations for the SDMT, as well as the correlation between its written and oral administrations, are all on the order of .80 for normal subjects (Lezak, 2004; Spreen & Strauss, 1998).

One problem with neuropsychological screening tests is that they are influenced by demographic variables such as age and education (Amante, Van Houten, Grieve, Bader, & Margules, 1977; Diehr, Heaton, Miller, & Grant, 1998; Heaton, Ryan, Grant, & Matthews, 1996; Smith, 1982; Tombaugh, 2003). Comprehensive neuropsychological assessment reduces this problem because one can select tests that are variously affected by these variables. In contrast, "screening" measures like the SDMT often have too few test variables to detect the influence of demographic variables,

* Corresponding author. Present address: M.A., c/o UM-MSU Longitudinal Study, 4660 S. Hagadorn Road, Suite 620, East Lansing, MI 48823, USA.

E-mail address: sherid41@msu.edu (L.K. Sheridan).

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doi:10.1016/j.acn.2005.07.003

Table 1
Normative SDMT data from previous research

Authors (year)/sample	*N*	Age range	Written *X* (S.D.)	Oral *X* (S.D.)
Bate et al. (2001)ˆ, normal controls (both genders)	35	30.2 (10.3)	58.6 (12.6)	n/a
Beatty, Paul, Blanco, Hames, & Wilbanks (1995)ˆ, normal controls (both genders)	32	44.8 (14.8)	n/a	59.0 (10.2)
Centofani (1975), volunteers	69	18–24	55.2 (7.5)	62.7 (9.1)
	72	25–34	53.6 (6.6)	61.2 (7.8)
	76	35–44	51.1 (8.1)	59.7 (9.7)
	75	45–54	46.8 (8.4)	54.5 (9.1)
	67	55–64	41.5 (8.6)	48.4 (9.1)
	61	65–75	37.4 (11.4)	46.2 (12.8)
Cutler (1968), college students	53	n/a	57.7 (n/a)	n/a
	49	n/a	51.9 (n/a)	n/a
	59	n/a	55.6 (n/a)	n/a
	45	n/a	59.5 (n/a)	n/a
D'Esposito et al. (1996), matched control sample (both genders)	15	n/a	n/a	63.1 (7.6)
Dowler et al. (1995), friends of SCI patients and other patients (both genders)[a]	64	n/a	53.2 (12.4)	n/a
Jorm et al. (2004),[a] males	1163	20–24	62.8 (10.2)	n/a
Community sample	1192	40–44	59.0 (9.1)	n/a
	1319	60–64	49.4 (9.5)	n/a
Females	1241	20–24	64.9 (9.9)	n/a
	1338	40–44	60.7 (9.4)	n/a
	1232	60–64	50.0 (10.0)	n/a
Nielsen, Knudsen, & Daubjerg (1989),[a] volunteers	35	20–29	52.4 (8.4)	n/a
	37	40–54	44.4 (10.6)	n/a
Nielsen, Lolk, & Kragh-Sorensen (1995), elderly volunteers	60	64–70	33.53 (9.38)	n/a
	36	70–74	27.94 (10.33)	n/a
	34	75–79	26.48 (8.64)	n/a
	21	80–83	20.24 (8.71)	n/a
Nissley & Schmitter-Edgecombe (2002), controls (both genders)	18	n/a	59.2 (9.7)	69.0 (11.3)
Selnes et al. (1991), gay/bisexual men[a]	309	25–34	58.4 (9.1)	n/a
	290	35–44	55.5 (9.0)	n/a
	97	45–54	52.9 (8.3)	n/a
Uchiyama et al. (1995), gay/bisexual men	481	20–29	57.3 (10.1)	n/a
	1596	30–39	56.13 (9.3)	n/a
	952	40–49	53.0 (9.3)	n/a
	252	50–73	50.1 (8.2)	n/a
Yeudall, Fromm, Reddon, & Stefanyk (1986), nonpsychiatric controls	62	15–20	59.3 (11.6)	70.7 (11.1)
	73	21–25	62.6 (8.4)	75.0 (10.5)
	48	26–30	59.6 (7.0)	69.1 (11.6)
	42	31–40	54.4 (7.6)	64.4 (8.7)
Males only	32	15–20	57.3 (9.4)	70.0 (10.6)
	37	21–25	61.0 (10.0)	73.1 (9.9)
	32	26–30	59.1 (7.9)	68.4 (13.7)
	26	31–40	52.2 (7.0)	62.0 (7.1)
Females only	30	15–20	61.8 (13.7)	71.7 (11.8)
	36	21–25	63.9 (6.8)	76.6 (10.9)
	16	26–30	60.6 (4.7)	70.6 (5.7)
	16	31–40	58.7 (7.2)	69.2 (9.7)

ˆWhen age range was not available, the age mean and S.D. of the sample is provided.
[a] Data are assumed to be from the written administration, although authors do not explicitly state the administration method.

and are frequently multifactorial leading to other possible vulnerabilities (Heaton et al., 1996). Given the monetary and temporal pressures experienced by clinicians, the use of robust, sensitive, and efficient screening measures is essential. Unfortunately, most screening tools are not well evaluated in this regard.

In the test manual for the SDMT, Smith (1968, 1982) reported normative data for students and adults with various disorders, but not normative data for adults without disorders. In an addition to Smith's (1968) original work, Centofani (1975) published an adult norm supplement by providing means and standard deviations for 18–75 years old non-clinical adults. Although sample size per age range are approximately equal, gender breakdowns were not reported. Cutler (1968, as cited in Smith, 1982) provides mean SDMT scores, without age or gender breakdowns, for college students. Thus, the lack of age and gender breakdowns in the extant literature limits the value of the SDMT when assessing new cohorts against current normative data. Also, SES and education effects have not been addressed.

Table 1 summarizes the extant literature with respect to non-clinical adult written and oral performance on the SDMT. Studies suggest that in ages greater than 55 years, there is a lowering of SDMT performance (Jorm, Anstey, Christensen, & Rogers, 2004), but no systematic effect across normal younger individuals. Based on previously published studies, we generated aggregated means and standard deviations for both written and oral SDMT for adults less than 30 years of age, adults 30–55 years, and adults older than 55 years. The mean score, across gender, for young adults (<30 years) was 58.2 (range = 51.87–63.93, S.D. = 9.1) on the written administration and 69.4 (range = 62.70–76.59, S.D. = 10.6) on the oral administration. Individuals in middle adulthood (30–55 years) had a mean score of 53.2 (range = 44.4–58.7, S.D. = 8.9) on the written administration and a mean score of 59.5 (range = 54.5–69.2, S.D. = 9.2) on the oral administration. Older adults (those over 55 years) had a mean score of 35.8 (S.D. = 9.6) on the written administration and a mean of 47.3 (S.D. = 11.0) on the oral administration.

Although there are sufficient data to support that increasing age affects both written and oral SDMT performance, we do not have enough information about the effects of education, gender, intelligence, socioeconomic status, and ethnicity to enable clinicians to rely on this screening instrument. These factors have been cited as possible confounds in normative data research (Diehr et al., 1998; Heaton et al., 1996; Smith, 1982; Tombaugh, 2003). Our goal was to add to the extant literature by examining the effect of age, education, gender, and income levels concurrently on SDMT, using a community based sample from the Michigan Longitudinal Study (Zucker et al., 2000).

1. Method

1.1. Participants

These data are part of an ongoing community-based, longitudinal study of families at high risk for alcohol use disorders. The study's criterion for alcoholism risk for children was assessed via paternal alcohol use, with a community contrast group of control subjects. These procedures are more fully discussed in previous work (Zucker et al., 2000). Since the current study aimed to provide normative data, only those SDMT data from adults without an alcoholism diagnosis were included in the analyses. The sample (N = 238; 73 males and 165 females) were those who completed the SDMT during the first wave of data collection of the Michigan Longitudinal Study (when the age range was between 21 and 49). Participants did not have any major medical or psychiatric illnesses.

2. Measures

2.1. Demographic variables

Gender, age, education, and income were obtained from a demographic questionnaire. For ease of presentation, age, education, and income were recoded into discrete categories. Age was recoded into two groupings: 20–29 and 30–39. Although Table 2 presents descriptive data on those aged 40 and older, the N for this age range was small, so they were excluded from statistical analyses. Education was divided dichotomously into those with the equivalent of a high school education (≤12 years) and those with more than a high school education (≥13 years). Income was recoded into two groups (≤$30,000 and ≥$30,001) because there is evidence that socioeconomic status affects neuropsychological test findings (Amante et al., 1977).

Table 2
Descriptive statistics by level of education, age, and gender

Age	*N*	Male written	Male oral	*N*	Female written	Female oral
<12 years education						
20–39	6	50.0 (13.7)	58.8 (15.2)	33[a]	52.9 (9.4)	58.7 (11.5)
30–39	8	53.0 (7.9)	61.0 (9.3)	31	51.1 (8.1)	59.8 (9.9)
40–49	1	49 (n/a)	61.0 (n/a)	1	34 (n/a)	45 (n/a)
>12 years education						
20–39	15	55.0 (11.4)	65.7 (13.0)	29	57.7 (7.9)	64.8 (8.8)
30–39	37	52.9 (9.3)	62.9 (13.0)	69[b]	57.7 (9.3)	66.4 (11.1)
40–49	6[c]	53.0 (7.0)	66.8 (6.4)	2	54.0 (8.5)	60.0 (14.1)

[a] One woman had a missing oral score data.
[b] Three women had missing oral score data.
[c] One man has a missing written score data.

2.2. *Symbol Digit Modalities Test (Smith, 1968, 1982)*

The SDMT requires individuals to identify nine different symbols corresponding to the numbers 1 through 9, and to practice writing the correct number under the corresponding symbol. Then they manually fill the blank space under each symbol with the corresponding number. A second oral administration is then completed. The participant is given a blank copy of the test and asked to state the correct number for each corresponding symbol. The participant is given 90 s to complete each of these administrations. A written and oral score is calculated by totaling the number of correct answers for each section. Oral and written administrations provide two different indices of functioning, which assess attention, scanning abilities, and motor skills (Lezak, 2004).

3. Results

The breakdown of SDMT performance on the written and oral administrations, by age, education, and gender is shown in Table 2. The pattern of Pearson correlations between SDMT scores and age and education varied. The correlations between age and both written and oral administration scores were non-significant (*r*s = .06 and .11, respectively), regardless of whether the analysis was run across or separately by gender. In contrast, the correlations were significant between education and written ($r = .23$, $p < .05$) and oral scores ($r = .25$, $p < .05$). However, when examined separately

Table 3
MANOVA results from normal control sample

Variable	Written		Oral	
	X (S.E.)	Univariate *F* (*df*)	*X* (S.E.)	Univariate *F* (*df*)
Gender (multivariate *F* (2, 208) = 1.9; NS)		2.2 (1)		.18 (1)
Males	51.8 (1.8)		61.1 (2.2)	
Females	54.8 (.82)		62.6 (1.0)	
Education (multivariate *F* (2, 208) = 1.9; NS)		2.8 (1)		3.8 (1)
<12 years	52.1 (1.6)		59.6 (2.0)	
>13 years	54.6 (1.0)		63.9 (1.3)	
Income (multivariate *F* (2, 208) = .35; NS)		.69(1)		.53(1)
<30K	52.2 (1.6)		60.7 (1.9)	
>30K	54.9 (.9)		63.3 (1.1)	
Age (multivariate *F* (2, 208) = .66; NS)		1.1 (1)		.29 (1)
20–29	54.9 (1.1)		62.8 (1.4)	
30–39	52.1 (1.5)		61.1 (1.8)	

Means presented are marginal means.

by gender, these effects were significant for women (written, $r = .37$, $p < .01$, oral, $r = .34$, $p < .01$), but not for men (rs = .13 and .14, respectively; $p > .05$).

We conducted a multivariate analysis of variance (MANOVA) using the written and oral administrations of the SDMT as dependent variables, utilizing age (20–39; 30–39), education (≤12 years, 13 or more years), gender, and annual income groupings (≤$30K; >$30K). None of the multivariate or univariate F tests were significant (all Fs < 3.64 (1, 224); NS). The results are shown in Table 3.

4. Discussion

These results indicate that the SDMT is not significantly affected across the age, gender, and income groupings analyzed. We also found a somewhat contradictory finding. That is, although education was not a significant factor in the MANOVA analyses, there were some significant correlations between education and SDMT scores in women. It is possible that our division of education groupings, despite previous research with similar groupings, artificially reduced the variance in education, and when coupled with other factors in the MANOVA, led to the nonsignificant finding.

The lack of correlation between education and SDMT scores in the male sample may be a combined issue of range restriction and a low *N*. All of the men in this sample had 12 years of education or more, whereas the women outnumbered men 2 to 1 and had a lower floor in years of education (lowest number of years education was 7). Other investigators have reported the confounding nature of education in neuropsychological measures (e.g., Diehr et al., 1998; Heaton et al., 1996; Smith, 1982; Tombaugh, 2003). Moreover, these data point to the additive influence of education on academic-related tasks. When the correlations were run for only individuals who had 13 or more years of education, only the relationship between women's education and written SDMT score reached significance ($r = .22$, $p < .05$).

While we might have studied additional markers of demographic status (e.g., ethnicity, handedness), there is no available published information spanning two or more key demographic variables arguing for differential performance on the SDMT along any demographic parameter other than age. The present study focused on younger to middle aged adults. It should be noted that while there was no effect of age on SDMT performance in the age ranges in the current study, it seems quite likely that had we studied older (50 years or older) participants we would have found the same decrements in performance others have reported in the literature. Unfortunately, the age range of our sample at initial data collection did not allow for older individuals to be assessed without potential practice effects.

This is a non-clinical, community-based sample whose SDMT performance is broadly consistent with what might be expected based upon published data to date. The fact that these participants were recruited through community canvassing is important because such samples are arguably more representative than those presenting themselves at medical facilities with a variety of motivations (Rush, Phillips, & Panek, 1978). Neuropsychologists want to anticipate how target populations might do on tests of general or specific neurocognitive abilities or skills, particularly when assessing how various subgroups of a population will perform. For screening measures such as the SDMT, this is of critical importance if the test results are to be used in a meaningful way in making statements about overall neuropsychological health. The SDMT is a good screening task for field investigations because it is brief, familiar to subjects, and readily scored. The results of the current study indicate that the SDMT is robust to the influence of demographic variables, which support the use of this measure in detecting neuropsychological impairment in non-clinical samples.

Acknowledgments

This research was supported by National Institute on Alcohol Abuse and Alcoholism grants R01 AA12217, R37 AA07065, and T32 AA07477 to R.A. Zucker, J.T. Nigg, and H.E. Fitzgerald.

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