

Normative data for the digit–letter substitution task in school children

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ABSTRACT

Background/Aims: To establish the norms for the substitution task, a measure of psychomotor performance.

Materials and Methods: Eight hundred and forty three school students were selected in the present study aged between 9-16 years (mean age = 12.14; SD = 1.77). Subjects were assessed one at a time for Digit-Letter Substitution Task (DLST).

Results: Both age and sex influenced performance on the DLST; therefore, correction scores were obtained on the basis of these factors.

Conclusions: The availability of the Indian normative data for the DLST will allow wider application of this test in clinical practice.

Key words: Information processing speed; psychomotor task; substitution; sustained attention.

INTRODUCTION

The cognitive demands of the Symbol Digit Modality Test (SDMT) include attention, visual scanning, and motor and psychomotor speed. The SDMT is purportedly sensitive to a wide range of neurologic and neuropsychiatric disorders but may lack disorder specificity.^[1] For example, SDMT was used as a screening instrument on 28 brain-damaged males in the age range of 8-16 years compared with 28 nondamaged matching controls. The performance of brain-damaged group was poor than the other group.^[2] Schizophrenia and depression have symptomatology of slowing in both motor and mental activities, denoted in depression as 'psychomotor retardation' and in schizophrenia as 'psychomotor poverty'. This was observed by writing movements recorded during the performance of the Digit Symbol Test (DST). It was observed that psychomotor performance was found to be slowing in both disorders.^[3] In another study 30 schizophrenic inpatients and 30 matched controls were digitally recorded during performance of the SDST. The study revealed that both matching time and writing time were longer in the schizophrenic patients.^[4] Anorexia nervosa patients were also found abnormal on the DST.^[5] A recent review of published SDMT normative data was based on the community based control sample across age, education, gender, and income groupings.^[6] Most studies have focused on adults aged over 60 years, which may be of limited utility to clinicians and investigators

working with a wider range of adults.^[7] Currently, normative data are unavailable for the Indian population.

The DLST was developed from Digit Symbol Substitution Test (DSST), one of the subsets of the Wechsler intelligence scale.^[8] Substitution tests are essentially speed--dependent tasks that require the subject to match particular signs – symbols, digits, or letters – to other signs within a specified time period. The DLST has the advantage of using letters and digits, signs that are already well known to those taking the test.^[9] Thus, there is no question of a need to learn new symbols while being tested. Such learning ability is definitely not the only aptitude studied for in the trial. For this reason, the DLST was used instead of the DSST.^[10] Substitution tasks involve visual scanning, mental flexibility, sustained attention, psychomotor speed, and speed of information processing.^[11]

The purposes of this study were to develop the normative data of a modified version DLST^[12] performance and provide normative data for clinical and research use from a large, nationally representative sample of Indian children population.

MATERIALS AND METHODS

Subjects

Eight hundred and forty three school students aged between 9-16 years (mean age = 12.14; SD = 1.77) were

selected for the present study. All of them were healthy and proficient in English. Participants were excluded from the study if they indicated that they had a history of neurological or psychiatric disturbance and were on medication affecting the central nervous system; or had had a history of learning disability. Following complete description of the study, written informed consent was obtained from the participants.

Instrument

The DLST test sheet is given in the Appendix. The DLST consisted of a worksheet, which has 8 rows and 12 columns and randomly arranged digits in rows and columns. The students are asked to substitute as many target digits as possible in the specified time of 90 seconds. The letter substitution may be undertaken in a horizontal, vertical, or randomized manner by selecting a particular digit. The total number of substitutions and wrong substitutions are scored. The net score was obtained by deducting wrong substitutions from the total substitutions attempted.^[12] Five trained assistants at the neuropsychological test laboratory administered tests.

Data analysis

The normative procedure for DLST scores involved the fitting of multiple linear regression models adjusted for age (in years) and sex. The core assumptions of regression analysis (homoscedasticity, normal distribution of the residuals, absence of multicollinearity, and absence of 'influential cases') were tested for each model. Homoscedasticity was evaluated by visual inspection of the scatter plots of the residuals on the predicted values. The normal distribution of the residuals was investigated by visual inspection of the histograms and the normal probability plots. The occurrence of multicollinearity was checked by calculating the Variance Inflation Factors (VIFs), which should not exceed 10.^[13] Cook's distances were computed to identify possible influential cases. Normative data can then be obtained by calculating the residuals for the DLST scores (e_i = observed score – predicted score). The residuals are then standardized ($Z_i = e_i/SD(\text{residual})$) so that the performance of the participant can be evaluated via a Z distribution table with cumulative probabilities. All analyses were performed using the SPSS 10.0 version software package.

RESULTS

Linear multiple regression models were fitted for the DLST scores. The residuals were sufficiently normally distributed, and no heteroscedasticity was observed. VIFs of the predictors in the regression models had a maximum value of 1.001, which is well below the cut-off value of 10.

The outliers had virtually no effect (maximum Cook's distance = .02).

Table 1 presents the regression models. Age and sex had a significantly positive and negative ($P < 0.001$) influence on the predicted DLST scores. The predicted DLST scores of females were significantly higher ($P < 0.001$) than those of males.

Combining these regression models with the standard deviations of the residuals provides normative data. First, the predicted values of the scores (predicted y_i) for the DLST are calculated by inserting the coded values of the predictor variables in the regression models [Table 2]. Next, the residuals of both scores are calculated (e_i = observed y_i – predicted y_i) and then standardized ($Z_i = e_i/SD(\text{residual})$). The SD (residual) equals 10.41 for the DLST scores.

Multiple linear regressions provided a multiple R value of 0.688 with a corresponding R^2 determination index of 0.474, indicating that 47% of the score variance was explained by the combination of age and sex. The model equation was: DLST score = $-13.45 + 5.313 \times \text{Age} - 5.647 \times \text{sex}$. This indicates that for each progressive year of age, the DLST score increases, on average, by 5.31 and decreases by -5.65 for each sex. These coefficients allowed us to calculate the correction scores to apply to individual subjects in order to consider the effects of age and sex. Table 3 provides normative DLST data based on the regression models in Table 2 stratified by age and sex. If an individual is 9, 10, . . . , 16 years.

DISCUSSION

The results found that scores were positively correlated for both age and sex, and females outperformed males in DLST performance. The present study had similar finding on earlier study, that the Letter–Digit Substitution Test (LDST) was administered to cognitively screened sample of adults. Age was the most important predictor of LDST performance, and females outperformed males.

Table 1: Mean and standard deviation of digit-letter substitution task scores stratified by age and sex

Age (years)	Females		Males	
	n	Mean \pm SD	n	Mean \pm SD
9	10	35.5 \pm 6.69	18	29.44 \pm 6.01
10	70	39.57 \pm 9.76	93	34.02 \pm 6.68
11	41	43.46 \pm 10.14	98	39.08 \pm 8.69
12	50	48.74 \pm 9.23	121	43.6 \pm 9.69
13	67	58.87 \pm 12.51	72	52.85 \pm 10.88
14	31	57.1 \pm 12.02	69	55.87 \pm 11.69
15	36	66.94 \pm 9.95	45	60.73 \pm 16
16	10	72.9 \pm 10.31	12	56.58 \pm 11.45
Total	315	51.42 \pm 14.68	528	45.21 \pm 13.66

Table 2: Multiple linear regression models of the digit–letter substitution task scores with age and sex as predictors

Variables	B	Std. error	T	P values	Standardized B	VIF	R ²	SD (residuals)
Constant	–13.45	2.545	–5.285	<0.001	-	-	-	-
Age	5.313	0.203	26.199	<0.001	0.656	1.001	-	-
Sex	–5.647	0.743	–7.604	<0.001	–0.190	1.001	0.474	10.41

Table 3: Net digit-letter substitution tasks stratified by age and sex of raw scores of percentile

Percentile	Females								Males							
	Age (years)								Age (years)							
	9	10	11	12	13	14	15	16	9	10	11	12	13	14	15	16
5	26	23.55	24.3	31.65	40.6	41.6	52	55	21	22.7	24.95	29	35.65	36	27	37
10	26	26.1	27.6	34.2	44.8	43	54.7	55.9	21	25	27	30	38.6	41	46.2	37.3
25	30.5	32.75	36	42.75	48	48	60	70	24.75	28	33.75	37	47	49	50.5	51.75
50	36	40	45	50	59	55	65.5	72.5	30	34	39	44	53	56	60	55.5
75	38.5	46	50	53.25	67	72	71.5	75.5	32	39	45	49	60	63	68	63
90	48.1	53.9	52.8	61.9	72.2	74	81.9	94.1	37	42	50.1	56.8	63	72	86	74.1
95	-	56.35	61.5	64	81.6	77.2	86.65	-	-	45	54	61.9	68.4	73.5	96	-

Appendix: Digit letter substitutions test**Instructions:**

Substitute the digits with corresponding letter as per the given key.

Substitute as many possible within the given time.

Start and stop only when told.

Substitute Letters:

1	2	3	4	5	6	7	8	9
L	H	Y	N	R	E	D	T	J
6	2	4	1	5	7	9	3	2
5	4	7	8	1	2	3	4	9
2	4	6	7	8	9	3	1	2
2	9	4	6	8	1	2	5	9
9	7	4	2	3	8	1	5	6
8	6	2	3	9	4	5	7	1
3	5	9	1	2	5	6	2	7
5	4	9	2	7	1	3	2	8

The high level of education profoundly influenced LDST performance and high level of education had better performance than low level of education.^[9] The modified SDMT (M-SDMT) performance was influenced by race/ethnicity, age, education, and gender on the National Survey of American Life. African-Americans and nonLatino Whites (NLW) groups had similar M-SDMT performances, which differed from Caribbean Blacks.^[14] In contrast, the variables across age, education, gender, and socioeconomic status had no impact on SDMT performance and a robust screening test for community adult neuropsychological impairment.^[6]

The DLST used in earlier studies on 50 psychiatric inpatients were diagnosed having substance-related disorder, schizophrenia, bipolar disorder, depressive disorder, or anxiety disorder had low scores than normal volunteers,^[15] and also scores increased following consumption of coffee, a stimulant.^[12] To our knowledge, a prior study on the DLST^[12] reported a general description of performance but did not provide means or standard deviations of performance on this measure on children

population. Moreover, the effect of demographic variables on DLST performance had not been previously examined. However, examination of percentile ranks revealed an unstable pattern of DLST performance across age and gender groups. This study was limited to the children population and uneven cell sizes across derived age and sex. Further research with larger samples is needed to clarify this relation with adult age range. Nonetheless, these results permit quantitative evaluation of performance on the DLST in healthy school children. As the DLST is easy to administer in a less amount of time and potentially useful in the assessment of attention, neglect, and psychomotor ability,^[12] it is hoped that these normative data will increase its use in children clinical populations.

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