Discrete Norms and Regression-based Formulae for Interpreting The Minimal Assessment Of Cognitive Function In Multiple Sclerosis: A Canadian Normative Study

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INTRODUCTION

- Multiple Sclerosis (MS) is a progressive central nervous system disease which causes white matter lesions and gray matter atrophy in both the brain and/or spinal cord[1].
- Approximately 40-65% of individuals with MS experience cognitive dysfunction[2].
- The Minimal Assessment of Cognitive Function in Multiple Sclerosis (MACFIMS) is a consensus-based collection of neuropsychological tests designed to evaluate cognitive dysfunction in individuals with multiple sclerosis[3].
- The cognitive measures in the MACFIMS include: the Symbol Digit Modalities Test, oral version (SDMT)[4], Paced Auditory Serial Addition Test (PASAT)[5], Controlled Oral Word Association Test (i.e., FAS & Animals)[6], Judgment of Line Orientation Test (JOLO)[7], California Verbal Learning Test, 2nd Edition (CVLT-II)[8], Brief Visuospatial Memory Test-Revised (BVMT-R)[9], and the Delis Kaplan Executive Function System (D-KEFS) Sorting Test[10].
- It is typically scored using each respective published test manual leaving the examiner to make test interpretations from norms derived from different populations.
- The objective of the present research was to was to provide both discrete and regression-based normative data on the MACFIMS tests in a largely co-normed Canadian population to allow for improved psychometric interpretation.

METHODS

- This study aggregated MACFIMS data sets from across three Canadian cities (i.e., Ottawa, Toronto, London) yielding a total of 330 healthy control participants from four different studies evaluating cognition in individuals with MS.
- Discrete based norms were derived by dividing the dataset into age brackets and computing the mean (M) and standard deviation (SD).
- Regression based-norms were derived by computing a series of linear regressions.
- In each regression model, the raw scores on the subtests were the criterion variables. Age (in years), gender (coded as 2 = female, 1 = male), and education (in years) were the demographic predictor variables that were entered as a single block.
- For each regression model, the constant and unstandardized coefficients were used to generate normative formulae.

RESULTS

- Traditional age-based discrete norms were derived (see Table 1).
- Regression-based formulae controlling for demographics (sex, age, education) were derived (see Table 2).
- The various demographic variables varied in their contribution to each MACFIMS test in the regression models; predicting 0-18% of the variance.

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Table 1. Age Based Discrete Norms

	18-29			30-39			40-49			50-59			60-65		
MACFIMS test	M	SD	N	M	SD	N	M	SD	N	M	SD	N	M	SD	N
SDMT	66.66	9.55	80	64.52	10.48	82	58.68	6.98	85	58	9.06	69	50.92	8.35	12
2s PASAT	31.18	9.59	39	33.86	10.03	36	31.67	12.23	49	32.41	12.44	41	32.69	7.84	13
3s PASAT	47.42	8.27	79	49.1	7.72	82	46.12	10.62	84	47.07	12.21	70	48.85	7.55	13
FAS	42.64	12.76	39	40.84	7.97	37	42.04	10.13	49	45.48	11.22	42	43.23	8.24	13
Animals	25.54	5.09	39	26.08	5.44	37	23.27	3.87	48	24.45	4.78	42	22.85	6.39	13
JOLO	27.79	2.94	14	25.09	2.43	11	24.7	3.89	10	25.69	3.73	13	23	5.1	9
CVLT-II Free Recall	59.5	8.19	24	57.21	6.81	19	56.93	7.52	28	57.04	9.57	28	57.33	6.84	9
CVLT-II List B Free Recall	7	2.66	14	6.91	1.64	11	5.8	2.3	10	5.69	2.1	13	7	2.74	9
CVLT-II Short Delay Free	13.79	1.53	14	12.18	2.04	11	12.7	2.91	10	11.85	2.82	13	11.67	3.04	9
CVLT-II Short Delay Cued	13.86	1.75	14	13.27	1.74	11	13.2	2.35	10	12.15	2.79	13	11.67	2.18	9
CVLT-II Long Delay Free	14	1.75	14	12.91	1.7	11	13	2.75	10	12.15	3.11	13	11.78	2.73	9
CVLT-II Long Delay Cued	14	1.52	14	14	1.18	11	13.9	2.23	10	12.62	2.6	13	12.22	2.22	9
CVLT-II - Total Intrusions	1.93	2.13	14	0.91	1.38	11	1.1	0.88	10	1.85	2.27	13	3.56	2.07	9
CVLT-II - Total Repetitions	6.14	5.42	14	4.55	2.02	11	5.9	4.56	10	7.69	6.68	13	9.44	5.7	9
BVMT-R Total Recall	29.38	4.72	39	28.24	4.32	37	27.71	5.78	49	25.85	6.21	42	20.46	7.14	13
BVMT-R Learning	3.67	2.03	39	4.11	2.01	37	3.88	1.73	49	4.1	1.82	42	3.77	2.05	13
BVMT-R Delay Recall	11.14	1.41	29	10.38	1.27	29	10.16	1.73	31	10.14	2.13	27	9.23	1.83	13
BVMT-R Percent retained	97.9	5.15	29	93.85	6.65	29	94.61	7.58	31	97.69	4.61	27	99.15	3.08	13
D-KEFS Confirmed Correct Sorts	11.06	2.03	29	9.76	1.64	29	10.1	1.49	31	10.26	2.18	27	9.38	2.79	13
D-KEFS Free Sort Description Score	40.86	7.93	29	37.07	6.94	29	37.81	6.61	31	37.63	8.3	27	34.31	13.46	13

Table 2. Regression-based formulae controlling for demographics

MACFIMS test	N	Regression Based Formulae	Adj R^2	SE est	F
SDMT	328	70.62 + (sex*2.83) - (age*0.36) + (educ*1.00)	0.18	9.03	24.09
2s PASAT	178	21.49 - (sex*4.07) + (age*0.02) + (educ*1.10)	0.05	10.69	4.127
3s PASAT	328	39.24 - (sex*1.95) - (age*0.02) + (educ*0.82)	0.04	9.53	5.32
FAS	180	31.86 - (sex*0.87) + (age*0.09) + (educ*0.56)	0.01	10.5	1.39
Animals	179	22.53 - (sex*0.52) - (age*0.06) + (educ*0.35)	0.03	4.91	2.82
JOLO	57	36.64 - (sex*2.83) - (age*0.08) - (educ*0.20)	0.18	3.46	5.19
CVLT-II Free Recall	108	48.77 - (sex*0.33) - (age*0.08) + (educ*0.81)	0.04	7.84	2.6
CVLT-II List B Free Recall	57	4.42 - (sex*0.18) - (age*0.02) + (educ*0.22)	0.02	2.29	1.35
CVLT-II Short Delay Free	57	11.62 + (sex*0.22) - (age*0.06) + (educ*0.18)	0.07	2.43	2.39
CVLT-II Short Delay Cued	57	12.84 + (sex*0.62) - (age*0.07) + (educ*0.12)	0.13	2.12	3.72
CVLT-II Long Delay Free	57	11.53 + (sex*0.27) - (age*0.06) + (educ*0.23)	0.11	2.35	3.37
CVLT-II Long Delay Cued	57	12.91 + (sex*0.60) - (age*0.06) + (educ*0.12)	0.12	1.95	3.49
CVLT-II - Total Intrusions	57	-2.42 - (sex*0.32) + (age*0.04) + (educ*0.21)	0.06	1.93	2.28
CVLT-II - Total Repetitions	57	-1.49 + (sex*0.66) + (age*0.08) + (educ*0.25)	0	5.25	1.01
BVMT-R Total Recall	180	29.21 - (sex*0.30) - (age*0.16) + (educ*0.34)	0.12	5.54	8.86
BVMT-R Learning	180	4.89 - (sex*0.43) + (age*0.01) - (educ*0.04)	0	1.89	0.77
BVMT-R Delay Recall	129	11.89 - (sex*0.39) - (age*0.04) + (age*0.05)	0.08	1.66	4.67
BVMT-R Percent retained	129	91.72 + (sex*0.30) + (age*0.03) + (educ*0.18)	-0.02	6.21	0.34
D-KEFS Confirmed Correct Sorts	129	11.83 - (sex*1.23) - (age*0.01) + (educ*0.07)	0.07	1.93	4.12
D-KEFS Free Sort Description Score	129	41.67 - (sex*4.97) - (age*0.06) + (educ*0.49)	0.08	7.98	4.49

RESULTS (continued)

- The following tests and subtests were more influenced by demographic variables as measured with standardized β weights being greater than .20 (not presented but available from the first author; specific demographic variable listen in parentheses): SDMT (age), 2 & 3s PASAT (education), JOLO (sex, age), CVLT-II Free Recall (education), CVLT-II List B Free Recall (education), CVLT-II Short Delay Free Recall (age, education), CVLT-II Long Delay Free Recall (age, education), CVLT-II Long Delay Cued Recall (age), CVLT-II - Total Intrusions (age, education), CVLT-II - Total Repetitions (age, education), BVMT-R Total Recall (age, education), BVMT-R Delay Recall (age), D-KEFS Confirmed Correct Sorts (sex), and D-KEFS Free Sort Description Score (sex).

REGRESSION-BASED FORMULA EXAMPLE

- 45-year-old woman with MS with a grade 11 education whose FAS score = 25
- Input each of her demographic variables (i.e., sex=2, age=45, educ=11) into the FAS Regression Based Formulae in Table 2: 31.86 - (sex*0.87) + (age*0.09) + (educ*0.56)
- 31.86 + (2*0.87) - (45*0.09) + (11*0.56) = 35.71
- This predicted score is subtracted from her observed score, which is divided by the standard error of the estimate for that subtest (i.e., 10.5), to yield a z-score of -1.02 (i.e., [25-35.71]/10.5= -1.02)
- From an interpretive standpoint, this woman's observed score falls approximately 1 standard deviation below age-, education-, and gender-matched peers.

CONCLUSIONS

- The current study extends the normative data of the MACFIMS by providing discrete based (i.e., age bands) and regression-based (age-, gender, and education-corrected) scores for a large sample of Canadian adults.
- The provision of both discrete and regression-based options will allow clinicians the freedom to choose the scoring method best suited to their practice.
- Provision of these regression-based formulae will allow for more accurate interpretation of MACFIMS scores by allowing clinicians to correct for all relevant demographic variables simultaneously, leading to improved clinical decision making for individuals with MS.
- A limitation for this study (and others like it) is that for the measures with smaller than 100 subjects, the regression-based estimates have an expected margin of error (possibly overestimating the condition by 15%).

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