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Brief Communication

A French Version of a Voice Recognition Symbol Digit Modalities Test Analog

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ABSTRACT: We previously showed that a fully automated voice recognition analog of the Symbol Digit Modalities Test (VR-SDMT) is sensitive in detecting processing speed deficits in people with multiple sclerosis (pwMS). We subsequently developed a French language version and administered it to 49 French-Canadian pwMS and 29 matched healthy control (HC) subjects. Significant correlations between the VR-SDMT and traditional oral SDMT were found in the MS ($r = -0.716$, $p < 0.001$) and HC ($r = -0.623$, $p < 0.001$) groups. These findings in French replicate our previous findings and confirm the utility of voice recognition software in assessing cognition in pwMS.

Résumé : Version française d'un logiciel de reconnaissance de la voix, analogue du Symbol Digit Modalities Test. L'équipe a démontré, dans une étude antérieure, la sensibilité d'un logiciel de reconnaissance de la voix entièrement automatisé, analogue du Symbol Digit Modalities Test (VRSDMT), à déceler une détérioration de la vitesse de traitement de l'information chez les personnes atteintes de sclérose en plaques (SP). Les chercheurs ont par la suite élaboré une version française du logiciel et l'a soumise à 49 personnes de langue canadienne française, atteintes de SP, ainsi qu'à 29 témoins appariés, en bonne santé (BS). Des corrélations significatives ont été établies entre la version du VRSDMT et la version orale classique du SDMT chez les personnes atteintes de SP ($r = -0{,}716$; $p < 0{,}001$) et les sujets en BS ($r = -0{,}623$; $p < 0{,}001$). Les résultats de l'étude sur la version française concordent avec ceux obtenus dans l'étude antérieure, et confirment de ce fait l'utilité du logiciel de reconnaissance de la voix dans l'évaluation de la cognition chez les personnes atteintes de SP.

Keywords: Multiple sclerosis; SDMT; Information processing speed; French voice recognition cognitive testing

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Impaired information processing speed (IPS) is the most common cognitive deficit in people with multiple sclerosis (pwMS).[1] When processing speed falters, it may effect learning and memory, increase physical impairment, and worsen disease progression.[2,3] Currently, the single best psychometric test for measuring IPS in pwMS is the SDMT.[4] However, the traditional SDMT requires a trained tester which can limit its use in a busy neurology clinic.[5] To address this potential limitation, we previously developed a fully automated voice recognition analog of the SDMT (VR-SDMT) and demonstrated its strong convergent validity with the traditional oral SDMT.[6] We now present data demonstrating the findings in a French-Canadian speaking sample.

The entire study was undertaken in French. A sample of 49 pwMS and 29 age, sex, and education-matched healthy individuals were recruited from an outpatient MS clinic. Inclusion criteria included a neurologist-confirmed diagnosis of MS, ages 21–60 years, and no history of substance abuse, traumatic brain injury, severe mental illness, and other disease of the central nervous system.

Informed consent was obtained from all participants.

For the VR-SDMT, the computer begins by asking the participants for basic demographic information (age, sex, education level) and then administers an eye test to make sure the individual has corrected near vision (≤20/70). If the participant passes the eye test, the computer gives the VR-SDMT instructions and administers a practice trial before starting the test.

A description of the VR-SDMT has been published previously.[6] The speech recognition module utilizes Google's online speech recognition software. To summarize, two rows of nine boxes appear on a computer screen, one row with numbers 1 to 9 and the other row with nine different symbols. These rows

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Table 1: Demographic comparison between MS and HC participants

	MS ($n = 49$), Mean (SD), median [range], n (%)	HC ($n = 29$), Mean (SD), median [range], n (%)	t-test/ χ^2	p value
Age	41.10 (8.27)	42.28 (9.97)	$t = -0.561$	0.577
Gender (% female)	42 (85.7%)	23 (79.3%)	$\chi^2 = 0.538$	0.463
Education			$\chi^2 = 0.740$	0.691
Secondary, freq. (%)	16 (32.7%)	8 (27.6%)		
College, freq. (%)	19 (38.8%)	10 (34.5%)		
University, freq. (%)	14 (28.6%)	11 (37.9%)		
employment			$\chi^2 = 7.403$	0.007
Not working (%)	14 (28.6%)	1 (3.4%)		
Working (%)	35 (71.4%)	28 (96.6%)		
EDSS (median [range])	2.50 (0–6)			
Disease course				
RRMS, freq. (%)	44 (89.8%)			
SPMS, freq. (%)	1 (2.0%)			
PPMS, freq. (%)	1 (2.0%)			
CIS, freq. (%)	3 (6.1%)			
Years since diagnosis	8.16 (7.518)			
Using Disease modifying drug				
Yes, freq. (%)	33 (67.3%)			
No, freq. (%)	16 (32.7%)			
Type of test done first			$\chi^2 = 0.995$	0.318
Traditional Oral SDMT	23 (46.9%)	17 (58.6%)		
Auto-SDMT	26 (53.1%)	12 (41.4%)		

MS: multiple sclerosis; HC: healthy control; SD: standard deviation; EDSS: Expanded Disability Status Scale; RRMS: relapsing-remitting multiple sclerosis; SPMS: secondary multiple sclerosis; PPMS: primary progressive multiple sclerosis; CIS: clinically isolated syndrome.

constitute the matching symbol-number code. A third row with the nine symbols in a different order appears below the code. A voice then instructs the participants to start. Participants have to match the symbols with the corresponding number according to the code as quickly as they can. When they get to the end of the line, that is, the ninth symbol, it goes blank and then reappears with the 9 symbols in a different order. The process repeats itself eight times. At the end of the study, a total test time and mean time per line are calculated by the computer. The latter is taken as the primary VR-SDMT measure.

A counterbalanced design was used in order to control for practice effects between the VR-SDMT and the traditional French version of the oral SDMT. Half the participants in the MS and HC groups were administered the VR-SDMT first, and in the other half, the traditional SDMT was given first.

Demographic comparisons between MS and HC participants were conducted using t-tests and chi-square tests where appropriate. Pearson's correlations were calculated between the VR-SDMT and the traditional oral SDMT to determine convergent validity.

Demographic and disease-related data are presented in Table 1. Aside from employment ($\chi^2 = 7.403$; $p < 0.007$), there were no differences between the MS and HC groups.

Significant correlations (Convergent validity) between the VR-SDMT and traditional oral SDMT were found in the MS ($r = -0.716$, $p < 0.001$) and HC groups ($r = -0.623$, $p < 0.001$). Scatterplots comparing the performance on the VR-SDMT and the traditional oral SDMT are presented in Figure 1(a) and (b).

The EDSS correlated significantly with the VR-SDMT ($r = 0.447$, $p < 0.001$) and the traditional oral SDMT ($r = -0.552$, $p < 0.001$).

Our data show strong convergent validity between French versions of the VR-SDMT and traditional oral SDMT, both in people with MS and healthy controls. In doing so, we have replicated our earlier findings reported in a proof of concept study involving English-speaking participants.[6] In the English version, the correlations between the VR-SDMT and traditional SDMT were $r = -0.806$ for the MS group and $r = -0.629$ for the HC group (both significant to $p < 0.001$).

The reason for the inverse correlation in both language versions is that the traditional oral version of the SDMT is scored according to the number of correct responses obtained, whereas the VR-SDMT is scored according to mean time taken to complete the eight lines of nine matching symbol-digit pairs. A good performance on the traditional SDMT is therefore a higher score while for the VR-SDMT it is a faster (or lower) score.

There are two practical advantages to the VR-SDMT. The fully automated nature of the VR assessment ensures that the testing process is completely standardized and therefore removes the variability that comes with different testers. In addition, the ease of administration of the VR-SDMT extends to the scoring process. Results are automatically computed and are instantly available,

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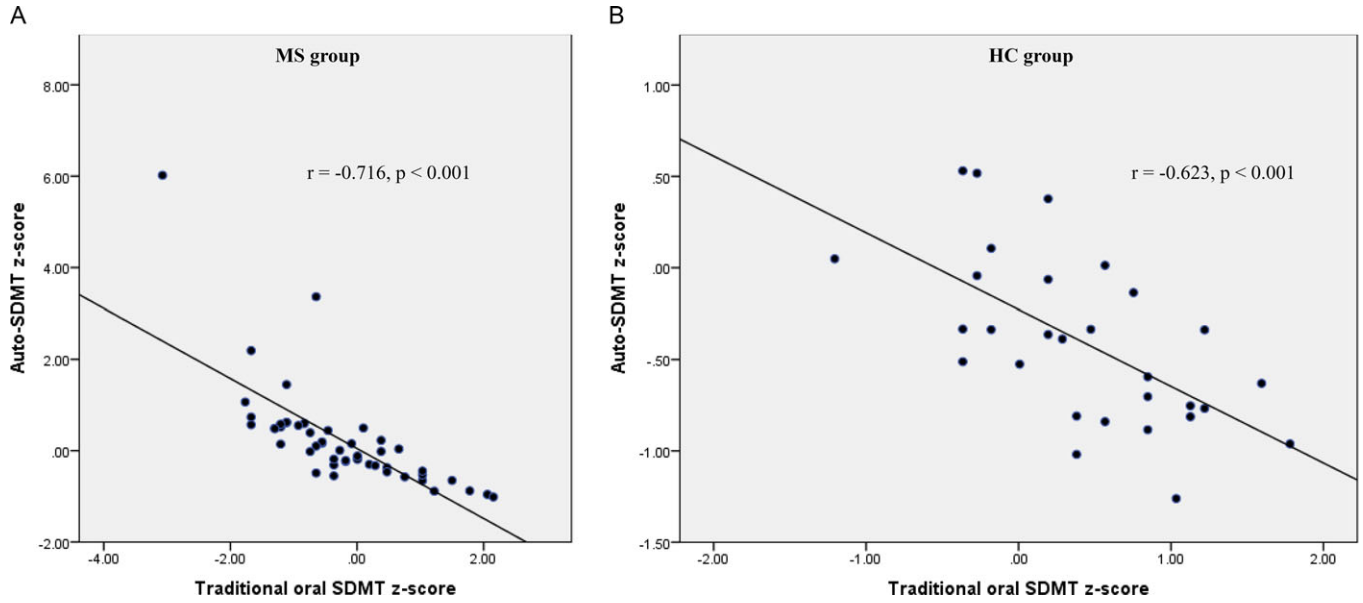


Figure 1: Comparison of performance on the auto-SDMT versus the traditional oral SDMT in people with multiple sclerosis (MS) (a) and healthy controls (HC) (b).

including in theory whether the participant has passed or failed the test based on a score of 1.5 standard deviations below the normative mean. These factors make the VR-SDMT suitable for a busy clinical practice where ease of administration and speed of assessment are paramount requirements.

The importance of all pwMS having a baseline cognitive assessment with regular cognitive monitoring thereafter has been highlighted in a recent consensus opinion.[7]

Completing a cognitive battery may not, however, be feasible in many centers given the limitations of time constraints and the absence of personnel with the psychometric expertise to undertake the testing.[5] It has therefore been suggested that as a bare minimum, the SDMT should be administered for a baseline assessment with yearly repetitions to gauge change over time.[7] To bypass the requirement of tester expertise, we developed our fully automated voice recognition analog. An alternative fully automated test also targeting processing speed is available for iPad use.[8] This too has been found to have strong convergent validity with the traditional oral version of the SDMT, but requires participants to have adequate dexterity in their hands/arm to touch the screen. This may preclude pwMS who have upper limb motor deficits. The VR-SDMT does not have this limitation, but like the traditional SDMT can prove problematic to administer in people with dysarthria.

While our primary aim was to determine the convergent validity of the VR-SDMT with the traditional version of the test, a limitation to our study was the absence of other cognitive data or imaging variables that would have allowed us to address construct validity as well. In relation to the latter, a well-replicated finding in the MS literature is the robust correlation between performance on the traditional SDMT and MRI indices of brain pathology, most notably thalamic atrophy.[9]

In summary, the development of a French version of a VR-SDMT analog extends the use of the test to a wider group of pwMS. The increasing sophistication of voice recognition software made freely available to researchers by Google opens the door to the development of additional language versions of the test. This offers clinicians the opportunity to add a quick, reliable marker of cognition to their assessment and treatment of pwMS.

Statement of Authorship. Author(s) and roles outlined. AF obtained funding; designed and conceptualized study; interpreted the data; drafted and revised the manuscript for intellectual content; approved final version of manuscript. LS programmed software (VR-SDMT); reviewed and revised the manuscript for intellectual content. JR programmed software (VR-SDMT); reviewed and revised the manuscript for intellectual content. CC played major role in the acquisition of data; reviewed and revised the manuscript for intellectual content. CB played major role in the acquisition of data; reviewed and revised the manuscript for intellectual content. CM analyzed data; drafted and revised the manuscript for intellectual content. JP played major role in the acquisition of data; reviewed and revised the manuscript for intellectual content. EL designed and conceptualized study; reviewed and revised the manuscript for intellectual content.

Conflicts of Interest. The author(s) declare the following potential conflicts of interest: AF reports grant support from the MS Society of Canada and the Canadian Institute of Health Research, book royalties from Johns Hopkins University Press, Cambridge University Press, Amadeus Press, and Glitterati Editions, and speaker's honoraria from Novartis, Biogen, Roche, and Sanofi-Genzyme. LS declares that there is no conflict of interest. JR declares that there is no conflict of interest. CC declares that there is no conflict of interest. CB declares that there is no conflict of interest. CM declares that there is no conflict of interest. JP declares that there is no conflict of interest. EL reports speaker's honoraria from Alexion, Novartis, Biogen, and Sanofi-Genzyme as well as consulting honoraria from Biogen, EMD Serono, Hoffmann La-Roche, Novartis, Pendopharm, Sanofi-Genzyme, Alexion, and Abbvie.

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Data Availability Statement. The data that support the findings of this study are available from the corresponding author, (AF), upon reasonable request.

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