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Modified Wisconsin Card Sorting Test (M-WCST): Normative Data for the Lebanese Adult Population

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ABSTRACT

The aim of this study was to generate normative data on the M-WCST in a Lebanese adult population and to examine the relationship between performance on this task and demographic variables. The sample consisted of 220 healthy adults aged between 18 and 64 years. Regression-based strategy was applied to generate normative data. The results showed a statistically significant effect of age and level of education on the M-WCST measures, whereas gender was not significant. Demographically calibrated percentiles and scaled scores were created. Finally, this study was the first to provide normative-adjusted tables for the M-WCST scores in Lebanon.

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Introduction

Executive functions are a set of multiple cognitive capacities that act in a coordinated way to control the actions, thoughts, and emotions as well as monitoring goal-directed behaviors (Stuss & Alexander, 2000). They include a wide range of skills such as inhibition, working memory, cognitive flexibility, planning and problem-solving (Chan, Shum, Toulopoulou, & Chen, 2008) (Wilson, Heugten, van Winegardner, & Ownsworth, 2017). These skills are crucial for successful cognitive and linguistic development, social adaptation, and performance in daily life situations.

The Modified Wisconsin Card Sorting Test (M-WCST) (Nelson, 1976; Schretlen, 2010), a simplified version of the Wisconsin Card Sorting Test (WCST; Berg, 1948), is a widely used instrument for assessing higher order cognitive functions related to the frontal lobes of the brain. The M-WCST consists of two sets of 24 cards instead of two groups of 64 cards excluding all those cards sharing more than one attribute (e.g., sharing both color and form) with a key card, in order to eliminate ambiguity in interpreting responses (Nelson, 1976). Contrarily to the standard WCST administration whereby participants must match each response card to a stimulus card according to a particular principle (color first), in the M-WCST whichever sorting category the examinee chooses first is designed as correct. In addition, the required number of consecutive correct sorts for completing a category is decreased from 10 in the WCST to 6 in the M-WCST. Moreover, after six consecutive correct sorts, the participant is informed that the rule has changed and he has to find another rule, while no information was given in WCST. Finally, Nelson redefined perseverative errors as any error in which the sorting category chosen is the same as that used for the immediately preceding response.

During performance on the M-WCST, Nagahama et al. (1996) reported an activation of the prefrontal cortex, parietal association cortex and the cerebellum and involvement of the dorsolateral prefrontal cortex. Successful M-WCST performance requires strategic planning, working memory

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and the inhibition of impulsive responses (Schretlen, 2010). Therefore, impaired performance on the M-WCST indicates executive dysfunction and cognitive deficits (Schretlen, 2010). Several studies have reported that performance on the M-WCST was impaired in a variety of patients believed to have executive dysfunction including mild cognitive impairment, Parkinson disease, Huntington's disease (Peinemann et al., 2005), dementia (Nedjam, Devouche, & Barba, 2004), left temporal lobe epilepsy (Giovagnoli, 2001), Alzheimer disease (Bondi, Monsch, Butters, Salmon, & Paulsen, 1993), schizophrenia (Chan et al., 2012) and traumatic brain injury (Fork et al., 2005).

Demographical variables such as age, education level and sex influence significantly the performance on this test. A study by de Zubicaray, Smith, Chalk, and Semple (1998) demonstrated that the number and percent of perseverative errors have been positively associated with age (de Zubicaray et al., 1998). Similarly, the study of Axelrod and Henry (1992) showed an increase in the number of perseverative errors after the age of 60 (Axelrod & Henry, 1992). As for the level of education, studies demonstrate that years of education have been negatively related to the number of perseverative and non-perseverative errors (de Zubicaray et al., 1998; Obonsawin et al., 1999) but positively associated with the number of categories (de Zubicaray et al., 1998; Lineweaver, Bond, Thomas, & Salmon, 1999). One study of Lineweaver et al. (1999) found that sex is associated with the number of non-perseverative errors in a way with male participants making more errors compared to females. However, many other studies show no sex differences for the performance on the M-WCST (Caffarra, Vezzadini, Dieci, Zonato, & Venneri, 2004; Obonsawin et al., 1999).

In addition to demographical factors, cultural aspects have a significant effect on the performance of this test. Several studies have revealed this significant difference between ethnically and culturally diverse samples on the original WCST scores: For example, the study of Kohli and Kaur (2006) revealed high significant differences between the mean scores on almost all WCST indices among the Western and the Indian populations (Kohli & Kaur, 2006). Similar studies, involving Taiwanese individuals, also showed lower performance for these groups on the WCST indices when compared to US norms (Shan, Chen, Lee, & Su, 2008).

In recent years, normative studies on M-WCST have been produced for English speaking, Italian, Chinese, and Latin American adults. While norms have been developed for Saudi Arabian citizens on the WCST (Al-Ghatani, Obonsawin, Binshaig, & Al-Moutaery, 2011), none are available for the M-WCST in the Arab world. The need to establish culture-specific normative data for M-WCST is particularly crucial for clinical neuropsychological evaluation. To answer this need, our aim in this study is to develop normative data on the M-WCST for the Lebanese adult population to accurately identify significant executive dysfunction.

Materials and methods

Participants

Our normative sample consisted of 220 healthy adults aged between 18 and 64 years. Participants were recruited through convenience sampling at local universities, municipal buildings, and schools in urban and suburban areas across Lebanon. In order to rule out any neurological or psychiatric condition affecting the mental status or the daily activity performance of the participant, a detailed cognitive and psychiatric history was obtained in addition to a medical and surgical background provided by certified therapists. Moreover, exposure to medications, their dosages, and duration of use were also reviewed. Eligible participants were selected according to the following criteria: (a) adults aged between 18 and 64 years, (b) spoke Arabic as their mother tongue, (c) scored within the normal range on the Mini Mental State Examination (MMSE) (cut-off for inclusion ≥23) (MMSE, Folstein et al., 2000, Wrobel et al., 2008), d) scored ≤4 on the Patient Health Questionnaire–9 (PHQ-9, Kroenke, Spitzer, & Williams, 2001). Participants with a history of head injuries or other medical/psychiatric conditions affecting their neuropsychological status were excluded.

This study was approved by the research Committee of the Neuroscience Research Center, Faculty of Medical Sciences, Lebanese University. Participants were informed of the purpose of the study upon recruitment. Prior to their participation in this study, all individuals gave their written informed consent. Privacy and confidentiality were respected. Prior to initiating the M-WCST test, data including socio-demographic characteristics (age, gender, marital status, and level of education) were collected.

Sample size calculation

The sample size was computed on the basis of results obtained from previous normative data for the M-WCST in a Spanish sample (Del Pino, Pena, Ibarretxe-Bilbao, Schretlen, & Ojeda, 2016). The following parameters were used: An effect size (Cohen's f^2) of 0.05, an assumed two-sided significance of 5%, a power of 80%, and a number of three predictors. This produced a total minimal sample size of 212 participants. The G-Power version 3.1.9.2 Kiel, Germany software was used for the sample size calculation.

Instrument administration

The M-WCST (Schretlen, 2010) consists of 4 key cards and 48 response cards. Each card depicts figures that vary vary in form (cross, circle, triangle, or star), color (red, blue, yellow, or green), and number (one, two, three, or four). Whichever sorting category, the examinee chooses first is designed as correct. During the administration, the examiner informs the subject whether his choice is correct or incorrect until he sorts correctly six consecutive cards. Then, the examiner indicates that the rule has changed and instructs him "try to find another rule". Whichever category the examinee chooses, second is designed as correct if it differs from the first category. As a result, the third sorting category is the one that has not been previously selected. The order of the next three categories is the same as that of the first three categories. The test continues until all six consecutive categories of cards are sorted or until the entire deck of 48 cards has been used.

The instruction was translated from English to Arabic by a bilingual translator. A forward translation from English to Arabic was produced, and then another bilingual speech and language therapist back-translated it into English. The Arabic version of the test was compared with the original and back-translated English versions in a series of emails with the publisher (PAR). Based on consensus, minor edits were made and the most appropriate Arabic version was chosen. A pilot test was performed with 20 participants to ensure proper functioning and comprehension of Arabic-language test instruction. Administration of the M-WCST lasted approximately 10–15 min per participant.

Study measurements

Three scores are calculated for the M-WCST:

(1) Number of Categories Correct: This criterion corresponds to the number of sequences of six consecutive correct responses that the participant has completed during the test. Scores may range from 0 to 6.
(2) Number of Perseverative Errors: This score represents the number of errors involving the same sorting category as the immediately preceding response even after changing the rule.
(3) Total Errors: Total number of errors includes the number of perseverative and non-perseverative errors.

Statistical analysis

Data entry and analyses were performed using the statistical software SPSS version 22.0. Descriptive statistics were reported using means and standard deviations (SD) for continuous variables and frequency with percentages for categorical variables. To develop normative data, the method based on regression models was applied for M-WCT measures following the same procedures as published by Rivera and Arango-Lasprilla (Arango-Lasprilla et al., 2017). Three steps were generated: (1) A multivariable regression model for each dependent variable was conducted to specify the predictive model including gender (1 for male and 2 for female), age centered (agec = age − 36), $agec^2$, and education (0 if participants had 1–12 years of education and 1 if the participant had more than 12 years of education) as predictors. The factor age centered and age^2 were added to avoid possible multicollinearity on test performance (Aiken, West, & Reno, 1991). If predicted variables were not statistically significant in this multivariate model with an alpha of 0.05, the non-significant variables were removed and the model was re-run. (2) Predicted scores were calculated using the multiple regression equation, based on β weight values for all four demographic variables and their predictive constant: $\hat{y}i = \beta 0 + \beta agec\ (agec) + \beta agec^2\ (agec^2) + (\beta Gender \cdot Genderi) + (\beta Educ \cdot Educi)$. (3) Residual values are calculated (ei = score observed − predicted score), then standardized (Zi = ei/SD [residual]) and finally converted to percentile values using the standard normal cumulative distribution function. For all multiple linear regression models, the following assumptions were evaluated: (a) multicollinearity by the values of the Variance Inflation Factor (VIF), which must not exceed 10, and the collinearity tolerance values, which must not exceed the value of 1 (Kutner, Nachtsheim, Neter, & Li, 2005), and (b) the existence of influential values by calculating the Cook's distance. The maximum Cook's distance value was related to a F (p, n − p) distribution. Influential values are considered when percentile value is equal to or higher than 50 (Cook, 1977; Kutner et al., 2005). All statistical tests were two-tailed, and the significance level was set at 0.05.

Results

Baseline characteristics of normative sample

Table 1 presents the baseline characteristics of the normative sample. Overall, 220 healthy adults were enrolled in the study of which 57.7% were females. The mean age was 35.9 (SD = 14) with an age range of 18 to 64 years. The education level varied from primary to university (range 5 to 23 years) with a high proportion of well-educated having more than 12 years of education (62.2%). All persons scored higher than 26 (M = 28.8, SD = 1.1) on the MMSE and lower than 4 (M = 2.5, SD = 1.3) on the PHQ-9.

Regression models

The final multivariate linear regression models for each M-WCST measures are shown in Table 2. For each regression model, the constant and unstandardized coefficients were used to generate normative formulae (Table 3).

Table 1. Baseline characteristics of the study participants.

Variables	All (*N* = 220)
Age (Mean ± SD)	35.9 ± 14.0
Gender (*n* %)	
Male	93 (42.3%)
Female	127 (57.7%)
Education level (*n* %)	
1 to 12 years	83 (37.7%)
>12 years	137 (62.3%)

Table 2. Final multiple regression models for M-WCST measures.

M-WCST measure	B	Standard error	t	p Value	R^2	SDe (Residual)
Categories number					0.084	0.55
Constant	5.432	0.138	39.39	<0.0001		
Agec	−0.006	0.003	−2.052	0.041		
Level of education	0.252	0.082	3.083	0.002		
Perseverative errors					0.170	1.89
Constant	2.298	0.542	4.242	<0.0001		
Agec	0.03	0.011	2.791	0.006		
$Agec^2$	0.002	0.001	2.021	0.045		
Level of education	−0.764	0.288	−2.657	0.008		
Total errors					0.167	3.13
Constant	4.487	0.897	5.005	<0.0001		
Agec	0.047	0.018	2.629	0.009		
$Agec^2$	0.003	0.001	2.086	0.038		
Level of education	−1.281	0.476	−2.690	0.008		

* Agec = (Age-36); $Agec^2 = (Age\text{-}36)^2$, Education is coded as 1 = ≤12 years, 2 = >12 years.

Table 3. Normative equations for M-WCST measures.

M-WCST measures	Normative equations*
Categories number	5.432+(−0.006× Agec)+(0.252× Education)
Perseverative errors	2.298+(0.03× Agec)+(0.002× $Agec^2$)+(−0.764× Education)
Total errors	4.487+(0.047× Agec)+(0.003× $Agec^2$)+(−1.281× Education)

*Agec = (Age-36); $Agec^2 = (Age\text{-}36)^2$, Education is coded as 1 = ≤12 years, 2 = >12 years.

M-WCST number of categories correct

As shown in Table 2, the final multiple linear regression model explained 8.4% of the variance in M-WCST number of categories correct. It also shows that the raw scores for correct categories increased significantly with years of education (p= .002) and decreased with age (p= .04). Thus, norms were adjusted according to these two variables (Table 4).

M-WCST number of perseverative errors

This score increased significantly in a linear fashion as a function of age (p =.006) and decreased in the function of years of education (p= .008). Thus, norms for the number of perseverative errors were adjusted according to age and level of education (Table 5). The amount of variance explained in M-WCST number of perseverative errors was 17%.

M-WCST number of total errors

Same as for the number of perseverative errors, Table 2 shows that age and education level affect significantly the total errors raw scores (p = .009, p= .008, respectively). The amount of variance explained in M-WCST number of total errors was 16.7%. Consequently, norms for these scores were adjusted according to these two variables (Table 6).

The assumptions of multiple linear regression analysis were met for all final models. There was no multicollinearity (the VIF values were below 10; VIF≤1.114; collinearity tolerance values of 0.898 did not exceed the value of 1) or influential cases (the maximum Cook's distance value was 0.279 in a F (2,217) distribution which corresponds to percentile 24).

Normative procedure

An example will be provided to explain the procedure to obtain a percentile range for a given raw score on the M-WCST. Thus, let us assume we need to find the percentile score for a 19-year-old girl with 13 years of education who scored a 6 on the M-WCST number of total errors: (1) Find in Table 4 the normative equation that will allow you to obtain the predicted M-WCST number of total errors

Table 4. Normative data for the M-WCST Number of categories stratified by age and education levels for Lebanon.

		Age (years)									
	Percentile	18–22	23–27	28–32	33–37	38–42	43–47	48–52	53–57	58–62	63–67
1 to 12 years of education	**95**	-	-	-	-	-	-	-	-	-	-
	90	-	-	-	-	-	-	-	-	-	-
	85	-	-	-	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-	-	-	-
	75	-	-	-	-	-	-	-	-	-	-
	70	-	-	-	-	-	-	-	-	-	-
	65	-	-	-	-	-	-	-	-	-	-
	60	-	-	-	6	6	6	6	6	6	6
	55	6	6	6	6	6	6	6	6	6	6
	50	6	6	6	6	6	6	6	6	6	6
	45	5	5	5	5	5	5	5	5	5	5
	40	5	5	5	5	5	5	5	5	5	5
	35	5	5	5	4	4	4	4	4	4	4
	30	4	4	4	4	4	4	4	4	4	4
	25	4	4	4	4	4	4	3	3	3	3
	20	3	3	3	3	3	3	3	3	3	3
	15	3	3	2	2	2	2	2	2	2	2
	10	2	2	2	2	2	2	2	2	2	1
	5	1	1	1	1	1	0	0	0	0	0
>12 years of education	**95**	-	-	-	-	-	-	-	-	-	-
	90	-	-	-	-	-	-	-	-	-	-
	85	-	-	-	-	-	-	-	-	-	-
	80	-	-	-	-	-	-	-	-	-	-
	75	-	-	-	-	-	-	-	-	-	-
	70	-	-	-	-	-	-	-	-	-	-
	65	-	-	-	-	-	-	-	-	-	-
	60	-	-	-	-	-	-	-	-	-	-
	55	6	6	6	6	6	6	6	6	6	6
	50	6	6	6	6	6	6	6	6	6	6
	45	6	6	6	6	6	5	5	5	5	5
	40	5	5	5	5	5	5	5	5	5	5
	35	5	5	5	5	5	5	5	5	5	5
	30	4	4	4	4	4	4	4	4	4	4
	25	4	4	4	4	4	4	4	4	4	4
	20	3	3	3	3	3	3	3	3	3	3
	15	3	3	3	3	3	3	3	3	3	3
	10	2	2	2	2	2	2	2	2	2	2
	5	1	1	1	1	1	1	1	1	1	1

for this girl. The M-WCST predicted the number of total errors would be calculated using the following equation:

$\hat{y}i = 4.487 + (0.047 \times \text{Agec}) + (0.003 \times \text{Agec}^2) + (-1.281 \times \text{Education})$, the

The girl's age is 19 thus Agec = 19–36 = −17, Agec^2 = 289.

Since the education level of the girl in the example has 13 years of education, the value is 2.

Thus, the predicted value equation: $\hat{y}i = 4.487 + (0.047 \times (-17)) + (0.003 \times 289) + (-1.281 \times 2) = 4.487 - 0.799 + 0.867 - 2.562 = 1.993$

(2) In order to calculate the residual value (indicated with an ei in the equation), we subtract the actual M-WCST number of total errors (she scored 6) from the predicted value we just calculated. In this case, it would be ei = 6–1.993 = 4.007. (3) Next, consult the SDe column in Table 3. Using this value, we can transform the residual value to a standardized z score using the equation zi = ei/SDe. In this case, we have 4.007/3.13 = 1.28. This is the standardized z score for a 19-year-old Lebanese girl with a 13 years of education and who scored a 6 on the M-WCST number of total errors which corresponds to the 10 percentile.

Table 5. Normative data for the M-WCST perseverative errors stratified by age and education levels for Lebanon.

		Age (years)									
	Percentile	18–22	23–27	28–32	33–37	38–42	43–47	48–52	53–57	58–62	63–67
1 to 12 years of education	**95**	-	-	-	-	-	-	-	-	-	-
	90	-	-	-	-	-	-	-	-	-	0
	85	-	-	-	-	-	-	-	-	0	1
	80	-	-	-	-	-	-	-	0	1	1
	75	-	-	-	-	-	-	0	1	1	2
	70	-	-	-	-	0	0	1	1	2	2
	65	0	0	0	0	0	1	1	2	2	3
	60	1	1	1	1	1	1	2	2	3	3
	55	1	1	1	1	1	2	2	2	3	4
	50	2	1	1	2	2	2	2	3	3	4
	45	2	2	2	2	2	2	3	3	4	4
	40	2	2	2	2	2	3	3	4	4	5
	35	3	3	3	3	3	3	4	4	5	5
	30	3	3	3	3	3	4	4	4	5	6
	25	4	4	4	4	4	4	4	5	6	6
	20	4	4	4	4	4	5	5	5	6	7
	15	5	5	5	5	5	5	6	6	7	7
	10	6	5	5	6	6	6	6	7	7	8
	5	7	7	7	7	7	7	7	8	9	9
>12 years of education	**95**	-	-	-	-	-	-	-	-	-	-
	90	-	-	-	-	-	-	-	-	-	-
	85	-	-	-	-	-	-	-	-	-	0
	80	-	-	-	-	-	-	-	-	0	1
	75	-	-	-	-	-	-	-	0	1	1
	70	-	-	-	-	-	-	-	0	1	2
	65	-	-	-	-	-	0	0	1	1	2
	60	0	-	-	0	0	0	1	1	2	3
	55	0	0	0	0	1	1	1	2	2	3
	50	1	1	1	1	1	1	2	2	3	3
	45	1	1	1	1	1	2	2	2	3	4
	40	2	1	1	2	2	2	2	3	3	4
	35	2	2	2	2	2	2	3	3	4	5
	30	2	2	2	2	3	3	3	4	4	5
	25	3	3	3	3	3	3	4	4	5	5
	20	3	3	3	3	4	4	4	5	5	6
	15	4	4	4	4	4	4	5	5	6	7
	10	5	5	5	5	5	5	6	6	7	7
	5	6	6	6	6	6	6	7	7	8	8

User-friendly method

The method explained above offers an accurate percentile of the M-WCST measures; however, it requires multiple computations by hand from the clinicians. Therefore, the authors have created tables to easily determine the estimated percentile of each raw score. Given the same example mentioned above for a woman who is 19 years old with a 13 years of education who scored a 6 on the M-WCST number of total errors, the following steps must be followed if using the simplified normative tables, (1) First, determine the appropriate table showing the correspondent score (number of categories, perseverations, and total errors scores) (e.g. Table 6). (2) Next, determine the level of education correspondent for the subject. Since this girl has 19 years of education, she falls into more than 12 years of education category. (3) Identify the individual's suitable age range. In this case, 19 falls into the first age category 18–34, first column. (4) Search in the age range column to find the raw score that the person obtained on the test. Reading Table 7, the score obtained by this girl corresponds to an approximate percentile of 10.

Discussion

The purpose of this study was to establish normative data on the M-WCST for the Lebanese population. These norms will be appropriate for clinical neuropsychological evaluation in Lebanon. Knowledge of

Table 6. Normative data for the M-WCST total errors stratified by age and education levels for Lebanon.

		Age (years)									
	Percentile	18–22	23–27	28–32	33–37	38–42	43–47	48–52	53–57	58–62	63–67
1 to 12 years of education	**95**	-	-	-	-	-	-	-	0	1	2
	90	-	-	-	-	-	-	0	1	2	3
	85	0	-	-	-	0	1	1	2	3	4
	80	1	0	0	1	1	1	2	3	3	4
	75	1	1	1	1	1	2	2	3	4	5
	70	2	1	1	2	2	2	3	4	4	5
	65	2	2	2	2	2	3	3	4	5	6
	60	2	2	2	2	3	3	4	4	5	6
	55	3	3	3	3	3	3	4	5	6	7
	50	3	3	3	3	3	4	4	5	6	7
	45	4	3	3	4	4	4	5	6	6	7
	40	4	4	4	4	4	5	5	6	7	8
	35	4	4	4	4	5	5	6	6	7	8
	30	5	5	5	5	5	6	6	7	8	9
	25	5	5	5	5	6	6	7	7	8	9
	20	6	6	6	6	6	7	7	8	9	10
	15	6	6	6	6	7	7	8	8	9	10
	10	7	7	7	7	7	8	8	9	10	11
	5	8	8	8	8	9	9	10	10	11	12
>12 years of education	**95**	-	-	-	-	-	-	-	-	-	1
	90	-	-	-	-	-	-	-	-	1	2
	85	-	-	-	-	-	-	-	1	2	3
	80	-	-	-	-	-	0	1	1	2	3
	75	-	-	-	-	0	0	1	2	3	4
	70	0	0	0	0	1	1	2	2	3	4
	65	1	1	1	1	1	1	2	3	4	5
	60	1	1	1	1	1	2	2	3	4	5
	55	2	1	1	1	2	2	3	4	4	5
	50	2	2	2	2	2	3	3	4	5	6
	45	2	2	2	2	3	3	4	4	5	6
	40	3	3	3	3	3	3	4	5	6	7
	35	3	3	3	3	3	4	4	5	6	7
	30	4	3	3	4	4	4	5	6	6	7
	25	4	4	4	4	4	5	5	6	7	8
	20	5	4	4	5	5	5	6	7	7	8
	15	5	5	5	5	5	6	6	7	8	9
	10	6	6	6	6	6	7	7	8	9	10
	5	7	7	7	7	7	8	8	9	10	11

the factors associated with the performance of the M-WCST would not only be beneficial in interpreting an individual's activity on the test, but it would also aid in understanding the cognitive mechanisms underlying this task's performance. This sample of healthy individuals recruited from a wide range of ages and education levels showed that these two variables correlate with various aspects of the performance on the M-WCST. To test the possibility of their contribution on the variability of performance for the M-WCST, linear regression models were generated showing the effect of age and years of education on all M-WCST scores: with a variance of 8.4% on the number correct categories raw scores, 17% of variance on the number of perseveration and 16.7% on number of total errors with no effect of gender on any of the M-WCST scores. These results are similar to those reported in previous studies suggesting no sex differences in the test's scores (Arango-Lasprilla et al., 2015; Caffarra et al., 2004; Obonsawin et al., 1999). In line with the findings of the other normative studies, the results from the current study suggest that gender should not be taken into consideration when generating norms for the M-WCST in Lebanon.

As a function of age, the number of perseverative and total errors increased linearly and the number of correct categories decreased. This general pattern concurs with previous literature that shows that the scores of correct categories lessen and the number of errors increases with higher age (Arango-Lasprilla et al., 2015; de Zubicaray et al., 1998; Obonsawin et al., 1999). However, errors scores decreased linearly as a function of education as well as inversely with the number of categories correct. This model corroborated previous research which has found higher education to be negatively associated with total errors and perseverative errors, as well as positively correlated with a number of correct categories (Lineweaver et al., 1999; Obonsawin et al., 1999). Consistently with the previous literature, education and age-adjusted norms should be generated.

This study is the first to generate norms for M-WCST across Lebanon and the Arab region and will have an important effect on the clinical neuropsychological assessments standards given that the Arabic Lebanese speaking clinicians are left with limited standardized testing options, using untranslated tests or translated but invalidated measures to assess and treat neurologically impaired patients. As mentioned by the International Test Commission (2010) and in the study of Arsenault Lapierre et al. in (2011), educational, cultural and linguistic factors influence the neuropsychological test performance (Arsenault-Lapierre et al., 2011). Therefore, the examination of the Lebanese cognitive performance is imperative in regards to developing norms and identifying significant executive dysfunction. The first rationale for studying this population is that there is no published literature on the neuropsychological test performance of the Lebanese adult population. Although published Arabic versions of some cognitive measures in Lebanon such as the MoCA are available (Nasreddine et al., 2005) and ongoing research projects on validation mBICAMS and VMAT exist (Zeinoun et al.), norm equivalence cannot be assumed. Therefore, establishing Lebanese normative data will fill an important gap in the current literature.

Although the norms provided for this study could be useful in other Arabic countries, more studies should be carried out in order to investigate the neuropsychological performance in the Arab world and confirm the cross-cultural use of these tests between Arab countries. For the M-WCST,

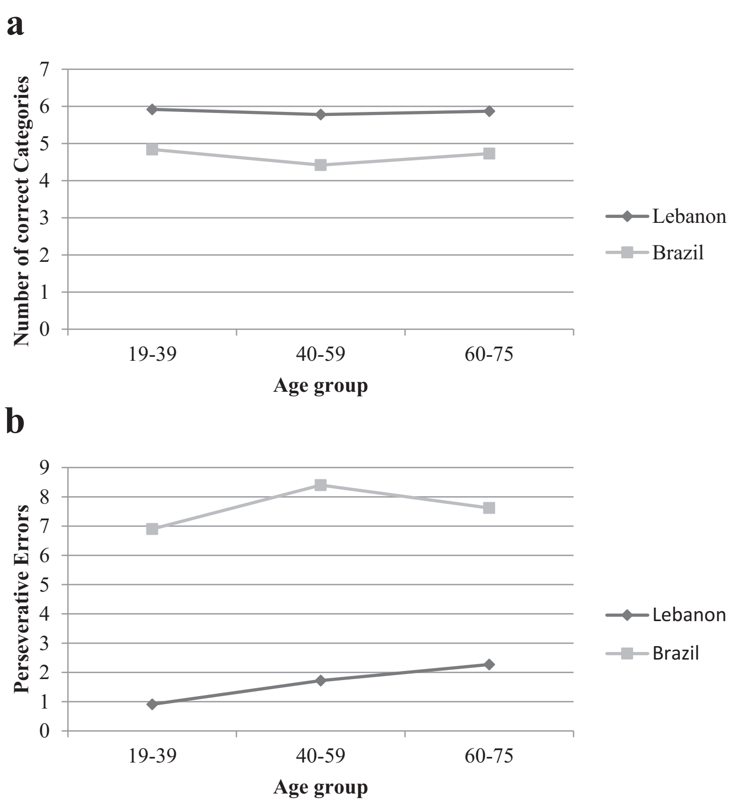

Figure 1. Comparison between the Lebanese and Brazilian norms among age groups in MWCST scores of: (a) Number of correct categories and (b) perseverative errors.

given that it is a nonverbal test and only the instructions were translated into the Arabic language, the cross-cultural effect may lessen. However, there is an increasing need for population-specific norms and validity research (Arsenault-Lapierre et al., 2011; Dion et al., 2014): The education level may alter the performance between different ethnic and cultural groups with people having lower education levels may be exposed to poorer health care or different cultures may have different educational, grading systems and multilingualism that might affect their performance. For example, in Lebanon, the literacy rate is estimated to be about 90% which differs from Egypt (74%) and Sudan (73%) (UNESCO, 2015). This cultural difference is presented when comparing the performance of the Lebanese population with the Brazilian subjects (Zimmermann, Cardoso, Trentini, Grassi-Oliveira, & Fonseca, 2015) showing the variance of the M-WCST indices (Figure 1).

Finally, several limitations were present in this study: First, the convenience sampling is highly vulnerable to selection bias; therefore, further studies should use a larger and more reliable sample for more representative data. In addition, this study included typically developed adults; thus, future studies should be conducted on children and on participants with different neurological or psychiatric conditions. Second, as mentioned earlier, the sample consisted of highly educated and mostly young participants which may limit the generalization of the current norms to all Lebanese adults. This may be related to the fact that illiterate individuals were ineligible to enroll in this research; therefore, older illiterate adults were excluded and leading to delimitation in the age ranges and education levels. Third, all participants were Lebanese speaking one, two or three languages, but no data were collected on multilingualism. Future research should study the effect of multilingualism on the M-WCST performance. Despite these limitations, establishing Lebanese norms for the M-WCST will offer a more effective characterization of executive functions abilities while taking into consideration the differences in the level of education and age which will, therefore, refine the clinical diagnosis.

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References

Aiken, L. S., West, S. G., & Reno, R. R. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage.

Al-Ghatani, A. M., Obonsawin, M. C., Binshaig, B. A., & Al-Moutaery, K. R. (2011). Saudi normative data for the Wisconsin Card Sorting Test, stroop test, test of non-verbal intelligence-3, picture completion and vocabulary (subtest of the wechsler adult intelligence scale-revised). *Neurosciences (Riyadh, Saudi Arabia)*, *16*(1), 29–41.

Arango-Lasprilla, J. C., Rivera, D., Longoni, M., Saracho, C. P., Garza, M. T., Aliaga, A., & Perrin, P. B. (2015). Modified Wisconsin Card Sorting Test (M-WCST): Normative data for the Latin American Spanish speaking adult population. *NeuroRehabilitation*, *37*(4), 563–590. doi:10.3233/NRE-151280

Arango-Lasprilla, J. C., Rivera, D., Nicholls, E., Aguayo Arelis, A., Garcia de la Cadena, C., Penalver Guia, A. I., … Sanchez-SanSegundo, M. (2017). Modified Wisconsin Card Sorting Test (M-WCST): Normative data for Spanish-speaking pediatric population. *NeuroRehabilitation*, *41*(3), 617–626. doi:10.3233/NRE-172242

Arsenault-Lapierre, G., Whitehead, V., Belleville, S., Massoud, F., Bergman, H., & Chertkow, H. (2011). Mild cognitive impairment subcategories depend on the source of norms. *Journal of Clinical and Experimental Neuropsychology*, *33*(5), 596–603. doi:10.1080/13803395.2010.547459

Axelrod, B. N., & Henry, R. R. (1992). Age-related performance on the wisconsin card sorting, similarities, and controlled oral word association tests. *Clinical Neuropsychologist*, *6*(1), 16–26. doi:10.1080/13854049208404113

Berg, E. A. (1948). A simple objective technique for measuring flexibility in thinking. *The Journal of General Psychology*, *39*, 15–22. doi:10.1080/00221309.1948.9918159

Bondi, M., Monsch, A., Butters, N., Salmon, D., & Paulsen, J. (1993). Utility of a modified version of the Wisconsin Card Sorting Test in the detection of dementia of the Alzheimer Type. *The Clinical Neuropsychologist*, *7*, 161–170.

Caffarra, P., Vezzadini, G., Dieci, F., Zonato, F., & Venneri, A. (2004). Modified Card Sorting Test: Normative data. *Journal of Clinical and Experimental Neuropsychology*, *26*(2), 246–250. doi:10.1076/jcen.26.2.246.28087

Chan, R. C. K., Shum, D., Toulopoulou, T., & Chen, E. Y. H. (2008). Assessment of executive functions: Review of instruments and identification of critical issues. *Archives of Clinical Neuropsychology*, *23*(2), 201–216. doi:10.1016/j.acn.2007.08.010

Chan, S. K. W., Chan, K. K. S., Lam, M. M. L., Chiu, C. P. Y., Hui, C. L. M., Wong, G. H. Y., … Chen, E. Y. H. (2012). Clinical and cognitive correlates of insight in first-episode schizophrenia. *Schizophrenia Research*, *135*(1–3), 40–45. doi:10.1016/j.schres.2011.12.013

Cook, R. D. (1977). Detection of influential observation in linear regression. *Technometrics*, *19*(1), 15–18.

de Zubicaray, G. I., Smith, G. A., Chalk, J. B., & Semple, J. (1998). The modified card sorting test: Test-retest stability and relationships with demographic variables in a healthy older adult sample. *The British Journal of Clinical Psychology*, *37*(Pt 4), 457–466. doi:10.1111/j.2044-8260.1998.tb01403.x

Del Pino, R., Pena, J., Ibarretxe-Bilbao, N., Schretlen, D. J., & Ojeda, N. (2016). Modified Wisconsin Card Sorting Test: Standardization and norms of the test for a population sample in Spain. *Revista De Neurologia*, *62*(5), 193–202.

Dion, M., Potvin, O., Belleville, S., Ferland, G., Renaud, M., Bherer, L., & Hudon, C. (2014). Normative data for the Rappel libre/Rappel indicé à 16 items (16-item Free and Cued Recall) in the elderly Quebec–French population. *The Clinical Neuropsychologist*, *28*, 1–19. doi:10.1080/13854046.2014.915058

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (2000). *Mini-mental state examination (Clinical Guide)*. Lutz, FL: Psychological Assessment Resources

Fork, M., Bartels, C., Ebert, A. D., Grubich, C., Synowitz, H., & Wallesch, C.-W. (2005). Neuropsychological sequelae of diffuse traumatic brain injury. *Brain Injury*, *19*(2), 101–108. doi:10.1080/02699050410001726086

Giovagnoli, A. R. (2001). Relation of sorting impairment to hippocampal damage in temporal lobe epilepsy. *Neuropsychologia*, *39*(2), 140–150. doi:10.1016/S0028-3932(00)00104-4

International Test Commission. (2010). *International Test Commission guidelines for translating and adapting tests*. Retrieved from http://www.intestcom.org

Kohli, A., & Kaur, M. (2006). Wisconsin Card Sorting Test: Normative data and experience. *Indian Journal of Psychiatry*, *48*(3), 181–184. doi:10.4103/0019-5545.31582

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9. *Journal of General Internal Medicine*, *16*(9), 606–613. doi:10.1046/j.1525-1497.2001.016009606.x

Kutner, M. H., Nachtsheim, C., Neter, J., & Li, W. (2005). *Applied linear statistical models*, Ed. 5. McGraw-Hill, New York.

Lineweaver, T. T., Bond, M. W., Thomas, R. G., & Salmon, D. P. (1999). A normative study of Nelson's (1976) modified version of the Wisconsin Card Sorting Test in healthy older adults. *The Clinical Neuropsychologist*, *13*(3), 328–347. doi:10.1076/clin.13.3.328.1745

Nagahama, Y., Fukuyama, H., Yamauchi, H., Matsuzaki, S., Konishi, J., Shibasaki, H., & Kimura, J. (1996). Cerebral activation during performance of a card sorting test. *Brain: A Journal of Neurology*, *119*(Pt 5), 1667–1675. doi:10.1093/brain/119.3.701

Nasreddine, Z., Phillips, N., Bedirian, V., Charbonneau, S., Whitehead, V., Collin, I., & Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*, 695–699. doi:10.1111/j.1532-5415.2005.53221.x

Nedjam, Z., Devouche, E., & Barba, G. D. (2004). Confabulation, but not executive dysfunction discriminates AD from frontotemporal dementia. *European Journal of Neurology*, *11*(11), 728–733. doi:10.1111/j.1468-1331.2004.00981.x

Nelson, H. (1976). A modified card sorting test sensitive to frontal-lobe defects. *Cortex*, *12*, 313–324.

Obonsawin, M. C., Crawford, J. R., Page, J., Chalmers, P., Low, G., & Marsh, P. (1999). Performance on the Modified Card Sorting Test by normal, healthy individuals: Relationship to general intellectual ability and demographic variables. *The British Journal of Clinical Psychology*, *38*(Pt 1), 27–41.

Peinemann, A., Schuller, S., Pohl, C., Jahn, T., Weindl, A., & Kassubek, J. (2005). Executive dysfunction in early stages of Huntington's disease is associated with striatal and insular atrophy: A neuropsychological and voxel-based morphometric study. *Journal of the Neurological Sciences*, *239*(1), 11–19. doi:10.1016/j.jns.2005.07.007

Schretlen, D. J. (2010). *Modified Wisconsin Card Sorting Test: M-WCST (Professional manual)*. Lutz, FL: Psychological Assessment Resources.

Shan, I., Chen, Y., Lee, Y., & Su, T. (2008). Adult normative data of the Wisconsin Card Sorting Test in Taiwan. *Journal of the Chinese Medical Association*, *71*(10), 517–522. doi:10.1016/S1726-4901(08)70160-6

Stuss, D. T., & Alexander, M. P. (2000). Executive functions and the frontal lobes: A conceptual view. *Psychological Research*, *63*(3–4), 289–298. doi:10.1007/s004269900007

UNESCO. (2015). *Literacy statistics metadata information table*. UNESCO Institute for Statistics. Retrieved from www.data.uis.unesco.org

Wilson, B., Heugten, C., van Winegardner, J., & Ownsworth, T. (2017). *Neuropsychological rehabilitation: The international handbook*. Abingdon, UK: Routledge.

Wrobel, N., & Farrag, M. (2008). Preliminary validation of an Arabic version of the MMSE in the elderly. *Clinical Gerontology*, *31*(3), 75–93. doi:10.1080/07317110802072223

Zimmermann, N., Cardoso, C. O., Trentini, C. M., Grassi-Oliveira, R., & Fonseca, R. P. (2015). Brazilian preliminary norms and investigation of age and education effects on the modified wisconsin card sorting test, stroop color and word test and digit span test in adults. *Dementia & Neuropsychologia*, *9*(2), 120–127. doi:10.1590/1980-57642015DN92000006