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Normative scores of the Wisconsin Card Sorting Test in a sample of the adult Portuguese population

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ABSTRACT

Objectives: The Wisconsin Card Sorting Test (WCST) is a neuropsychological instrument that is widely used for assessment of executive functioning in both clinical and research settings. The aim of this study was to provide the normative scores for the WCST in a sample of Portuguese healthy adults.

Methods: The data was collected from archival data in a total sample of 359 individuals, 149 men (41.5%, *Age* = 38.3; *SD* = 20.3) and 210 women (58.5%, *Age* = 52.2; *SD* = 19.4). Descriptive statistics were calculated to describe mean scores, standard-deviation and percentiles of the WCST indexes by gender, age and education. ANOVAs were used to explore the differences between these scores in sociodemographic variables. The normative scores were adjusted for age and educational level.

Results: Significant statistical differences in mean scores were found in several WCST indexes, such as, total errors, perseverations, perseverative errors and conceptual level responses regarding age and education. Percentiles for WCST indexes were stratified by age group and educational level.

Conclusions: Age and education are important factors explaining performance on the WCST. This is the first study focused on the development of WCST normative scores for the adult Portuguese population, which can be applied in clinical, educational and research contexts.

KEYWORDS

Healthy adults; normative scores; Wisconsin Card Sorting Test

Introduction

The Wisconsin Card Sorting Test (WCST) is a widely used neuropsychological assessment instruments to evaluate executive functions. Specifically, the WCST allows the assessment of the ability to generate, modify and apply a cognitive strategy in response to changing environmental contingencies (Berg, 1948; Grant & Berg, 1948; Heaton et al., 2005; Kopp et al., 2019). Adequate performance in this test relies on cognitive operations such as planning, systematic searching and updating cognitive sets based on external feedback with inhibition of preponderant responses (Heaton et al., 2005; Kopp et al., 2019). These processes belong to the domain of executive functions, which is a broader conceptualization for higher-order executive process (Diamond, 2013), associated with goal-directed behavior (Friedman & Miyake, 2017; Lezak et al., 2012).

Experimental and clinical neuropsychological research show that individuals with impaired performance on the WCST is associated with Dysexecutive Syndrome (DES), which is a cluster of symptoms typically related to brain impairment (Baddeley & Wilson, 1988; Halligan et al., 2004). DES is described as a pattern of dysfunction in cognitive flexibility, abstract reasoning, working memory, decision

making, planning, problem solving and behavioral regulation, being also defined as frontal lobe dysfunction (Wilson et al., 1998). However, recent evidence showed that DES is related to a widespread cortical and subcortical neural network (Eling et al., 2008; Nyhus & Barceló, 2009). Accordingly, the WCST performance is now attributed to multiple interconnected brain networks rather than a single structure as the frontal lobes (Eling et al., 2008; Lezak et al., 2012; Nyhus & Barceló, 2009; Strauss et al., 2006). The scientific debate is still underway due to the centrality of the frontal lobes in psychological process and specifically in executive functions (Kopp, Lange, et al., 2019; Miller & Cummings, 2018; Snyder, 2013; Stuss & Alexander, 2007).

Moreover, meta-analytic studies WCST performance deficits in psychiatric disorders, such as depression (Snyder, 2013), eating disorders (Roberts et al., 2007), obsessive-compulsive disorder (Shin et al., 2014) and attention deficit hyperactivity disorder (Romine et al., 2004), or neurological disorders, such as primary dystonia (Lange et al., 2016), amyotrophic lateral sclerosis (Lange et al., 2016) and Gilles de la Tourette (Lange et al., 2017). Even in low-powered or clinical studies, WCST deficits are described in dissociative disorders (Parlar et al., 2016; Prentice et al., 2008), depression (Galecki et al., 2015; Rady et al., 2012), bipolar disorder

(Fleck et al., 2008) alcohol use disorder (Spinola et al., 2017) and cocaine use disorder (Woicik et al., 2011).

In clinical settings, neuropsychological assessment by the WCST is based on the comparison of patient's performance with a standardized score or percentile, which allow to determine whether performance is higher or below the average of his/her normative group (Lezak et al., 2012). Previous studies showed that the WCST is sensitive to cultural differences in most WCST indexes, such as the *number of trials administered, correct responses, total number of errors or perseverative responses* (Coffey et al., 2005; Kohli & Kaur, 2006; Shan et al., 2008), which highlight the need to provide the normative scores for the WCST for different cultural backgrounds. The normative scores for the WCST can be found for different countries, such as China (Shan et al., 2008), India (Kohli & Kaur, 2006), North America (Heaton et al., 2005), Brazil (Trentini et al., 2010), Lebanon (Rammal et al., 2019), Argentina (Miranda et al., 2019) and Italy (Laiacina et al., 2000). However, the normative scores for the Portuguese population are still lacking.

Moreover, the role of sociodemographic variables on WCST performance are not fully understood. For instance, gender differences are not consistent (e.g. Heaton et al., 2005; Laiacina et al., 2000; Miranda et al., 2019), but Boone et al. (1993) found that female participants had better performance in the *trials administered, total errors, perseverative responses, perseverative errors, conceptual level responses, categories completed and trials to complete first category*. These differences were found in only middle to old age female participants. However, gender differences in executive functions are not consistent across studies, being probably related to sample bias or systematic error due to assessment instruments or the experimental tasks used in such studies (Grissom & Reyes, 2019; Mitrushina et al., 2005).

The relationships of age and education variables with WCST performance are documented in different studies (e.g. Ashendorf & McCaffrey, 2008; Fristoe et al., 1997; Heaton et al., 2005; Kohli & Kaur, 2006; Miranda et al., 2019; Mitrushina et al., 2005; Rammal et al., 2019; Rhodes, 2004; Stratta et al., 2001). Thus, executive functions may be sensitive to aging process, and to formal education possibly being explained by cognitive reserve (Roldán-Tapia et al., 2012), which impact on WCST performance (Lázaro et al., 2011; Rhodes, 2004). Younger individuals tend to have higher performance in efficient responses (e.g. *correct*

responses) and lower performance in non-efficient responses (e.g. *total errors, perseverations*) (Miranda et al., 2019; Rammal et al., 2019; Rhodes, 2004). Older adults with lower education reveal poorer performance in tasks of executive functioning (Martins et al., 2013). A similar effect may be described for education level, where individuals with higher education levels tend to have better performances in WCST (Boone et al., 1993; Heaton et al., 2005; Miranda et al., 2019; Shan et al., 2008). This effect tends to be more robust in the *number of categories completed* and *perseverative errors* in older individuals with less than 12 years of education (Rhodes, 2004).

There are several studies reporting the normative scores and the psychometric properties of the WCST for different countries. However, in Portugal the use of the WCST for clinical and research purposes is limited due to the absence of normative scores for this country. Therefore, this study aimed to provide the normative scores for the WCST according to a sample of the adult Portuguese population.

Method

Participants and procedure

The sample for this study was collected from control groups of different research projects in Portugal. The selection criteria for inclusion in the study were: (a) age above 18 years; (b) Portuguese nationality and living in Portugal for more than five years; (c) no psychiatric/neurological disorders. All participants gave informed consent for participation in a research study.

The total sample for this study consisted of 359 individuals (men 41.5%). The average age was 55 years ($SD = 15.1$) ranging from 18 to 90 years. The sample was stratified by sociodemographic characteristics as age, gender, and education. We divided our sample in the following groups: <6 years, 7–11 years and >12 years of education to have more balanced groups in terms of the number of cases. Years of formal education are defined by the number of years that individuals have attended formal education, namely, elementary, secondary, or higher education/university. Participants were divided into three age-groups according to Whitley et al. (2016) patterns of cognitive aging, specifically in three groups: 18–40 years old, 41–65 years old, and 66–90 years old (Table 1).

Table 1. Sociodemographic description ($N = 359$).

	Total sample ($n = 359$)		18–40 Years old ($n = 136$)		41–65 Years old ($n = 110$)		66–90 Years old ($n = 113$)	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Gender								
Men	149	41.5	65	47.8	41	37.3	43	38.1
Women	210	58.5	71	52.2	69	62.7	70	61.9
Educational Level								
<6 years	123	34.2	20	14.75	32	29.1	71	62.8
7–11 years	95	26.5	39	28.7	36	32.7	20	17.7
>12 years	141	39.3	77	21.4	42	38.2	22	19.5
Occupation								
Employed	204	56.8	115	84.6	81	73.6	8	7.1
Unemployed	23	6.4	11	8.1	12	10.9	0	0
Retired	120	33.4	0	0	15	13.6	105	87.5
Unknown	12	3.3	10	7.4	2	1.8	0	0

The analysis on these data was approved by the ethics committee of the host institution of this study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Measures

Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) is a test developed to assess executive functions (Berg, 1948; Heaton et al., 2005) consisting of four target cards and 128 response cards. Each card represents different forms (crosses, circles, triangles, or stars), colors (green, yellow, blue and red) and number of figures (one, two, three or four figures). The task is to match (color, shape, or number) each card from a deck of 128 cards that are provided to the participant one by one to the target cards. The WCST is scored on eleven performance parameters, namely: *trials administered*; *correct responses*; *total errors*; *perseverative responses*; *perseverative errors*; *non-perseverative errors*; *conceptual level responses*; *categories completed*; *trials to complete first category*; *failure to maintain set* and *other responses*. Raw scores were used in statistical analysis. WCST was administered according to the standards provided in the manual of Heaton and colleagues (2005).

Statistical analysis

The data processing and statistical analysis was conducted with the Statistical Package for the Social Sciences (IBM SPSS Statistics, version 24.0 for Windows). Normal distribution was assumed ($N > 30$), and multicollinearity was analyzed and showed to be adequate for all statistical procedures (Pallant, 2007). Descriptive analysis and WCST normative scores based on mean values, standard deviation and percentiles were performed. To explore the differences in mean scores between groups for the performance indicators of the WCST in sociodemographic variables as gender, age, and education, different Analyses of Variance (ANOVA), were performed. Post-hoc analyses with

Bonferroni correction were used to explore further the differences between these groups.

Results

The sample comprised 149 men (41.5%) and 210 women (58.5%), 123 with <6 years of study (34.2%), 95 with 7–11 years of study (26.5%) and 141 with >12 years (39.3%). Regarding professional occupation, 204 were employed (56.8%), 23 were unemployed (6.4%), 120 were retired (33.4%) and 12 did not described any occupation (3.3%), as depicted in Table 1.

Table 2 describes the comparisons between categories for gender, age groups and level of education. The alpha level was set at .05 for significant tests. A statistically significant difference between gender was found only in *conceptual level responses* ($F = 4.840$, $p = .020$). Regarding age groups, the younger group had lower scores comparing to middle-age and older groups in *trials administered* ($F = 35.023$, $p < .001$), *total errors* ($F = 54.896$, $p < .001$), *perseverations* ($F = 51.152$, $p < .001$), *perseverative errors* ($F = 52.812$, $p < .001$) and *non-perseverative errors* ($F = 12.994$, $p < .001$), which is consistent with the observed pattern, revealing a relationship of age in WCST performance. In the *trials to complete first category*, there were no differences between the younger and the middle-age group, but both groups were statistically different from the older group ($F = 15.734$, $p < .001$). In *conceptual level responses*, the middle group had higher scores than the other two groups ($F = 14.960$, $p < .001$).

Regarding education, significant differences were found between age groups in most of WCST indexes ($p < .001$). Individuals with lower education (<6 years) had consistently higher scores in total errors ($F = 71.318$, $p < .001$), and perseverations ($F = 69.388$, $p < .001$), and lower scores in conceptual responses ($F = 18.745$, $p < .001$), and categories completed ($F = 59.219$, $p < .001$), that the middle (7–11 years) and higher education (>12 years) groups. However, in the failure to maintain set and other responses indexes, differences were not significant.

The normative data are described in Table 3. Poorer performance was observed with increasing age. Regarding the comparisons between education levels by age groups, higher education was associated with better performance in most of

Table 2. Means and standard deviations of WCST indexes for healthy Portuguese individuals ($N = 359$).

WCST indexes	Gender			Age group			Education level		
	<i>F</i>	<i>p</i>	<i>Bc</i>	<i>F</i>	<i>p</i>	<i>Bc</i>	<i>F</i>	<i>p</i>	<i>Bc</i>
Trials administered	0.040	0.84	W = M	35.023	0.00	Y < M < O	36.916	0.00	L > Me > H
Correct responses	0.521	0.47	W = M	19.348	0.00	Y < M > O	24.233	0.00	L < Me = H
Total errors	0.020	0.88	W = M	54.896	0.00	Y < M < O	71.318	0.00	L > Me > H
Perseverations	0.058	0.80	W = M	51.152	0.00	Y < M < O	69.388	0.00	L > Me = H
Perseverative errors	0.042	0.83	W = M	52.812	0.00	Y < M < O	72.730	0.00	L > Me = H
Non-perseverative errors	0.730	0.39	W = M	12.994	0.00	Y < M < O	15.195	0.00	L = Me > H
Conceptual level responses	4.840	0.02	W > M	14.960	0.00	Y < M > O	18.745	0.00	L < Me < H
Categories completed	0.015	0.90	W = M	51.076	0.00	Y > M > O	59.219	0.00	L < Me = H
Trials to complete 1st category	2.394	0.12	W = M	15.734	0.00	Y = M < O	15.028	0.00	L > Me = H
Failure to maintain set	0.883	0.34	W = M	3.564	0.02	Y < M > O	0.062	0.94	L = Me = H
Other responses	0.681	0.42	W = M	0.177	0.84	Y < O	0.126	0.88	L = Me = H

W: women; M; men; Y = 18–40; M = 41–65; O = 65–90; L = <6 years; Me = 7–11 years; H = >12 ; Bc: Bonferroni Correction.

Table 3. Means and standard deviations of WCST indexes for healthy Portuguese individuals ($N = 359$).

Note: ** $p < .001$; ns: non-significant.

A significant relationship was found between age and performance in WCST performance, revealing poorer performance in this test with increasing age. This result is in line with previous literature, where age-related differences were found in WCST performance (Ashendorf & McCaffrey, 2008; Fristoe et al., 1997; Heaton et al., 2005; Kohli & Kaur, 2006; Miranda et al., 2019; Rhodes, 2004). A possible explanation may be related to the effects of brain aging in executive functioning. Despite recent discussions regarding neuroanatomical structures of executive functions

(Kopp et al., 2019; Miller & Cummings, 2018; Nyhus & Barceló, 2009; Snyder, 2013; Stuss & Alexander, 2007), the prefrontal cortex is widely accepted as one of the major structures of the frontal lobe implicated on executive functioning (Miyake et al., 2000; Shimamura, 2000). The prefrontal cortex tends to deteriorate with age (Raz, 2000), which may help explaining an age-related decline in performance of this test (Rhodes, 2004). According to Ashendorf and McCaffrey (2008), poorer cognitive flexibility, perseveration, alongside with declines in working memory/speed of processing and inefficiency in using environmental feedback may contribute to explain the impacts of aging in WCST performance. Age-related changes in those cognitive processes might account for the observed differences in WCST performance by age groups.

Education level was also associated with WCST performance. Individuals with higher education group (>12 years) had consistently better performance in WCST than lower education group (<6 years). This is also in line with previous research (Boone et al., 1993; Heaton et al., 2005; Miranda et al., 2019; Rammal et al., 2019; Shan et al., 2008). However, differences were not found between middle education and higher education group in *correct responses*, *total errors*, *perseverations*, *perseverative errors*, *categories completed*, *trials to complete first category*, *failure to maintain set* and *other responses*. This result may imply that individuals with lower education levels may have more difficulties on the WCST task than individuals with middle education and higher education level. In this sense, formal education may have a positive role in the development of cognitive skills associated with the executive functions, being related with WCST performance (Heaton et al., 2005; Miyake et al., 2000; Miyake & Friedman, 2012). Formal educational and contextual learning experiences may foster the development of executive functions, because of the increasing exposure to reading and verbal habits, visual and abstract reasoning exercises, mathematics and problem-solving tasks and meta-cognitive reflection (Lázaro et al., 2011).

However, these results should be interpreted with caution given the limitations related to the sample. It is worth noting that this study was conducted with archival data, which precluded the conduction of a prior power analysis. Thus, for the same reasons, it was not possible to ascertain temporal stability or to compute *learning to learn* index in the WCST. More research is required to explore in more depth the validity of WCST, specifically with clinical samples.

Conclusions

This is the first study focused on the development of normative scores for the WCST in the adult Portuguese population. These results highlight the association of age and education in WCST performance, which is in line with previous findings of the relationship between normal aging process and years of education in the executive functioning.

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No potential conflict of interest was reported by the author(s).

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