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Spanish Multicenter Normative Studies (NEURONORMA Project): Norms for the Stroop Color-Word Interference Test and the Tower of London-Drexel

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Abstract

As part of the NEURONORMA project, we provide age- and education-adjusted norms for the Stroop color-word interference test (SCWT)-Golden version and the Tower of London-Drexel University version (TOL^{DX}). The sample consists of 344 and 347 participants, respectively, who are cognitively normal, community dwelling, and ranging in age from 50 to 90 years. Tables are provided to convert raw scores to age-adjusted scaled scores. These were further converted into education-adjusted scaled scores by applying regression-based adjustments. Demographic variables, age, and education significantly affect scores of the SWCT and TOL^{DX}, sex, however, was found to be unrelated to performance in this sample. The normative data presented here were obtained from the same study sample as all the other NEURONORMA tests. In addition, the same statistical procedures for data analyses were applied. These co-normed data allow clinicians to compare scores from one test with all tests.

Keywords: Demography; Educational status; Reference values; Color perception; Reading; Problem solving

Introduction

The Spanish multicenter normative studies (NEURONORMA) project (Peña-Casanova et al., 2009) attempts to provide useful norms for people aged over 49 years for commonly used neuropsychological tests. In this paper, we provide normative

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data for the Stroop color-word interference test (SCWT; Golden, 1978; Stroop, 1935) and the Tower of London-Drexel University version (TOL^{DX}; Culbertson & Zillmer, 1998a).

Stroop Color-Word Interference Test

This test is a measure of cognitive flexibility, selective attention, cognitive inhibition, and information processing speed (Bryan & Luszcz, 2000; Rosselli et al., 2002; Van der Elst, Van Boxtel, Van Breukelen, & Jolles, 2006). Data from studies with fMRI strongly suggest that the inferior frontal, dorsolateral prefrontal and anterior cingulate cortices are involved in tasks such as Stroop test in which maintaining attentional control over conflicting responses is needed (Egner & Hirsch, 2005; Harrison et al., 2005; Peterson et al., 1999). A number of versions of the SCWT have been developed (for reviews see Lezak, Howieson, & Loring, 2004; Mitrushina, Boone, Razani, & D'Elia, 2005; Steinberg, Bieliauskas, Smith, & Ivnik, 2005 [selective review of studies that address the effects of subject variables]; Strauss, Sherman, & Spreen, 2006). The tests are based on the fact that it takes a longer time to call out the color names of colored forms than to read words, and even longer to name the color of the ink in which a color name is printed when the print ink is a color different from the color name (Dyer, 1973). This decrease in color-naming speed is called the color-word interference effect or Stroop effect (Lezak et al., 2004; Strauss et al., 2006). Poor performance on the SCWT has been found in a wide variety of patient groups. A review of this topic is, however, beyond the objective of this paper (for reviews see Lezak et al., 2004; Mitrushina et al., 2005; Strauss et al., 2006). Cognitive control in the SCWT is implemented by medial and lateral prefrontal cortices that bias processes in regions that have been involved in high-level perceptual and motor processes (Egner & Hirsch, 2005), and the task is consistent with a network model of SCWT performance (Peterson et al., 1999).

Demographic effects such as age, education, and sex have been frequently associated with SCWT scores. Age accounts for a significant amount of variability in the interference scores (the Golden version, Mitrushina et al., 2005). Aging produces a slowing in color naming and an increase in the interference effect (Bryan & Luszcz, 2000; Cohn, Dustman, & Bradford, 1984; Graf, Uttl, & Tuokko, 1995; Lucas et al., 2005; Moering, Schinka, Mortimer, & Graves, 2004; Uttl & Graf, 1997; Van der Elst et al., 2006). A recent study suggests that the age difference in Stroop interference is partially attributable to general slowing, but is also due to age-related changes in task-specific processes such as inhibitory control (Bugg, DeLosh, Davalos, & Davis, 2007; Connor, Franzen, & Sharp, 1988; Troyer, Leach, & Strauss, 2006). Age and error scores on the interference trial are positively correlated, indicating decreased accuracy with age (Troyer et al., 2006; Van der Elst et al., 2006).

Gender differences on the SCWT performance have been studied. For studies, sex has only a minor influence on Stroop test performance at any age (MacLeod, 1991), and for others those differences are simply absent (Anstey, Matters, Brown, & Lord, 2000; Ivnik et al., 1996) or minimal (Lucas et al., 2005). However, several investigators found interesting sex differences on the performance of the SCWT, with female advantage over men (Moering et al., 2004; Strickland, D'Elia, James, & Stein, 1997; Van der Elst et al., 2006).

Education has some effect on the SCWT score in adults (Anstey et al., 2000; Ivnik et al., 1996; Lucas et al., 2005; Steinberg et al., 2005; Van der Elst et al., 2006). In addition to previous data (Strickland et al., 1997), it was found that in Afro-American education had a strong effect on SCWT scores, accounting for 8%–26% of the variance, followed by sex and age (Moering et al., 2004). However, in another study on Afro-American age and education each accounted for about 8%–9% of the variance in performance on the interference trial (Lucas et al., 2005).

There are a number of studies that provide normative data for the different languages that the SCWT has been adapted to (Lezak et al., 2004; Mitrushina et al., 2005; Strauss et al., 2006). Specifically, there are some studies that provide normative data in Spanish language. Artiola, Hermosillo, Heaton, and Pardee (1999) studied Golden's version of the SCWT in a Spanish sample, aged from 18 to 65+ years, of 250 residents from the Madrid region (Spain) and in 185 Spanish speakers from the U.S.-Mexico border region. Rosselli and colleagues (2002) obtained normative data on 40 English monolinguals, 71 Spanish-English bilinguals, and 11 Spanish monolinguals in south Florida. Lopez, Salazar, Villaseñor, Saucedo, and Peña (2003 [cited in Mitrushina et al., 2005]) studied the effects of demographic variables on a series of neuropsychological tests including the SCWT (the Golden version). The total sample included 115 monolingual Latino men. Norms in Spanish for children were provided by Armengol (2002).

Tower of London

This test was originally developed by Shallice (1982) to assess higher-order problem solving and, specifically, executive planning abilities in subjects with damage to frontal lobes (for antecedents and modifications of the TOL see Culbertson & Zillmer, 2001, and Lezak et al., 2004). The test consists of two boards with pegs and several beads with different colors

(green, red, and blue). The subject must look ahead to determine the order and the number of moves necessary to rearrange the beads from their initial position to a new set of predetermined positions on one or more of the pegs. The constraints are: (a) only one bead may be moved at a time; (b) each bead may be moved only from peg to peg; and (c) only a specified number of beads may be left on each peg at a time (Lezak et al., 2004; Shallice, 1982). Levels of difficulty of the TOL items depend on the complexity of subgoals required to achieve the predetermined position. There are several variants of the test (for a review see Lezak et al., 2004), including a version published by the Drexel University (TOL^{DX}) (Culbertson & Zillmer, 1998a, 1998b, 2001).

This test is somewhat controversial because, although it is used to measure executive planning abilities (Sullivan et al., 2009), other factors are also important for successful performance, such as response inhibition, visuospatial memory, and working memory (Carlin et al., 2000; Phillips, Wynn, Gilhooey, Della Sala, & Logie, 1999; Zook, Davalos, DeLosh, & Davis, 2004). Moreover, a number of issues remain unaddressed in the literature, such as the problem structure, or problem space of the task, the impact of the modifications of the original, the variety of performance measures that can be derived (Berg & Byrd, 2002), and the impact of instructions, cuing, and learning processes as determinants of TOL performance (Unterrainer, Rahm, Leonhart, Ruff, & Halsband, 2003). In fact, neuroimaging studies show that using the TOL during planning activities a wide series of brain structures are activated, and in a similar manner to the SCWT, the TOL task is consistent with a network of areas which are not “simply” related to the prefrontal cortex. These include the dorsolateral prefrontal cortex, the anterior part of the cingulate cortex, the cuneus, the precuneus, and the supramarginal and angular gyri in the parietal lobe (Boghi et al., 2006; Lazeron et al., 2000; Newman, Carpenter, Varna, & Just, 2003).

Few studies have reported normative data and the demographic factors influence on the performance of the TOL test. Concerning age, the original normative sample of the TOL^{DX} recruited in three sites in the USA and four in Canada presented only age differences for the oldest group (+60 years), which were specifically related to the number of errors, number of total movements, and number of total time violation (Culbertson & Zillmer, 2001). However, age effect in TOL performance has not been clearly supported by other investigations. In fact, Bryan and Luszcz (2000) only found a small but significant negative correlation between age and performance on the TOL test, and Zook, Welsh, and Ewing (2006) concluded that the age differences in TOL-R (TOL-revised, Schnirman, Welsh, & Retzlaff, 1998) were eliminated after adjusting for individual differences in reasoning performance.

Few data on the influence of education or sex on the TOL performance have been provided. Some authors conclude that this task is not significantly influenced either by education (Zook et al., 2006) or gender (Culbertson & Zillmer, 2001).

At present, no normative data in the Spanish population for any version of TOL tasks have been published. Our study is the first attempt to provide standards for the performance on the Drexel University version of TOL in a Spanish sample.

The normative data of SCWT and TOL^{DX} presented in this paper are a part of a co-norming project that includes a wide range of neuropsychological tests. Co-norming clearly facilitates accuracy in cognitive pattern analysis in clinical settings.

Materials and Methods

Research Participants

We offer here a summary of the socio-demographic and participant characteristics of the entire NEURONORMA sample which have been reported in detail in a previous paper (Peña-Casanova et al., 2009). This is an observational cross-sectional study performed in nine services of neurology in Spain. Ethical approval for the study was granted by the Research Ethics Committee of the Municipal Institute of Medical Care of Barcelona. The ethnic background of all participants was Caucasian, and all were Spanish speakers.

Entry criteria included cognitively normal, consecutive individuals according to a series of inclusion and exclusion criteria. Cognitive normalcy was validated via informants, an ADL scale (the Interview for Deterioration of Daily living in Dementia; Böhm et al., 1998 [Spanish validated version]; Tenisse, Derix, & Crever, 1991), and a cognitive screening test, the minimal state examination (Blesa et al., 2001 [Spanish validated version]; Folstein, Folstein, & McHugh, 1975). As in the MOANS projects, volunteers did not need to be completely medically healthy to participate (Pedraza et al., 2005). Subjects with active, chronic medical, psychiatric, or neurological conditions or with physical disabilities were included if the researcher judged that the condition was correctly controlled or resolved and did not cause cognitive impairment. The same criterion was applied in the case of use of psychoactive medications. A total of 344 subjects were studied for the SCWT and 347 for the TOL^{DX}. Basic demographic information concerning both tests is presented in Table 1.

Table 1. Sample size by demographics and test

	SCWT		TOL ^{DX}	
	N	Percent	N	Percent
Age group				
50–56	75	21.80	76	21.90
57–59	51	14.83	51	14.70
60–62	34	9.88	34	9.80
63–65	18	5.23	18	5.19
66–68	25	7.27	25	7.20
69–71	47	13.66	48	13.83
72–74	32	9.30	32	9.22
75–77	30	8.72	31	8.93
78–80	20	5.81	21	6.05
>80	12	3.49	11	3.17
Education (years)				
≤5	73	21.22	71	20.46
6–7	24	6.98	25	7.20
8–9	66	19.19	66	19.02
10–11	40	11.63	39	11.24
12–13	36	10.47	36	10.37
14–15	32	9.30	34	9.80
≥16	73	21.22	76	21.90
Gender				
Men	134	38.95	140	40.35
Women	210	61.05	207	59.65
Total sample	344		347	

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Neuropsychological Measures

The neuropsychological measures were administered as part of a larger test battery, the NEURONORMA battery (Peña-Casanova et al., 2009). Tests were administered and scored by neuropsychologists specifically trained for this project.

Stroop Color-Word Interference Test

Golden's version of the SCWT (Golden, 1975) was used in this project. This version consists of a word page (p. 1) with 100 color words printed in black ink, a color page (p. 2) with 100 "Xs" printed in color (red, green, and blue), and a color-word page (p. 3) with 100 words from the first page printed in colors from the second page (the color and the word do not match). Subjects are asked to read down the columns starting with the top word in the leftmost column. After 45 s, the item last named on each stimulus card is noted. The test produces three scores: The word reading (W) score consists of the number of items completed on p. 1; the color-naming (C) score is made up of the number of items completed on p. 2; and the color-word (CW) score is made up of the number or items completed on p. 3. Standard administration procedures were followed as indicated in the test manual (Golden, 1978).

Tower of London-Drexel University Version

Although similar to the Tower of London originally developed by Shallice (1982), the Drexel University version (Culbertson & Zillmer, 2000) presents a number of modifications in administration and test scoring. This test uses two boards with three pegs ("tower boards"): On one the examiner places three colored wooden balls (blue, green, and red) in a goal position, and on the other there are three colored wooden balls that the subject must rearrange from a standard start position to the examiner's model. Ten problems are given in the order of increasing difficulty. Two minutes are allowed for each trial.

The original boards were substituted by larger ones previously developed in the context of this project. The test was administered and scored following the manual.

In this project, five different scores were obtained from both number or moves, and also successful completion and timing aspects. Here follows a brief extract of the scoring method from the test manual (for details see Culbertson & Zillmer, 2001).

- (a) Total correct score: The correct score is equal to the number of test problems solved with the minimum number of moves (in fact without extra moves). A total correct score of 10 is the upper limit.
- (b) Total moves score: The total moves score constitutes the primary score and is based on the number of moves the examinee executes in solving a test problem. A move has occurred when a ball is completely removed from a peg and then is either placed on another peg or replaced on the same peg. The minimum number of solution moves for each task problem is subtracted from the examinee's actual move count to determine the move score. The total moves score is the sum of the move scores for each of the individual test problems. The total moves score can range from 0 to 145.

Three time scores are calculated for each configuration: First, the initiation time score, defined as the time from the presentation of a test problem by the examiner to the initiation of the first problem-solving move (time limit cannot exceed 120 s for each configuration). Second, the execution time score, representing the time from the initiation of the first move to the completion or discontinuation of problem solving (maximum time allowed for each configuration is 120 s). Third, the problem-solving time score, defined as the interval from the presentation of a test problem to its completion or discontinuation by the participant (i.e., problem-solving time = initiation time + execution time). Considering that the time limit for each configuration is 2 min, the maximum time entry for any problem is 120 s. From the time scores of each problem, three total derived variables are obtained.

- (c) Total initiation time score, defined as the sum of the initiation time scores of the 10 test problems.
- (d) Total execution time score, defined as the sum of the execution time scores of the 10 problems.
- (e) Total problem-solving time score, defined as the sum of the problem-solving time scores of the 10 problems.

Statistical Analysis

Considering that the ability to compare all co-normed test scores directly with each other facilitates clinical interpretation of neuropsychological test profiles, a uniform normative procedure was applied to all measures as in the MOANS studies (Ivnik et al., 1992, 1996; Lucas et al., 2005).

The overlapping interval strategy (Pauker, 1988) was adopted to maximize the number of subjects contributing to the normative distribution at each mid-point age interval. Effects of age, sex, and education on raw subtest scores were studied using coefficients of correlation (r) and determination (r^2 ; Lucas et al., 2005). The frequency distribution of the raw scores (RS) was converted into age-adjusted scaled scores, NSS_A (NEURONORMA scaled score-age adjusted), following the methodology described by Ivnik and colleagues (1992). For each age range, a cumulative frequency distribution of the RS was generated. Raw scores were assigned percentile ranks in function of their place within a distribution. Subsequently, percentile ranks were converted to scaled scores (from 2 to 18) based on percentile ranges. This transformation of RS to NSS_A produced a normalized distribution (mean = 10; $SD = 3$) on which linear regressions could be applied. Years of education were modeled using the following equation: $NSS_A = k + (\beta \times \text{Education})$. The resulting equations were used to calculate age- and education-adjusted NEURONORMA scaled scores ($NSS_{A\&E}$) for each variable. The regression coefficient (β) from this analysis was used as the basis for education adjustments. A linear regression was employed to derive age- and education-adjusted scaled scores. The following formula outlined by Mungas, Marshall, Weldon, Haan, and Reed (1996) was employed: $NSS_{A\&E} = NSS_A - (\beta \times [\text{Education} - 12])$. Following the method described by Mungas and colleagues

Table 2. Correlations (r) and shared variances (r^2) of raw scores with age, year of education, and sex

Measure	Age (years)		Education (years)		Sex	
	r	r^2	r	r^2	r	r^2
SCWT						
Part A: Word	-0.3278	0.10746	0.52403	0.27461	-0.035	0.00122
Part B: Color	-0.4785	0.22892	0.47209	0.22287	0.06718	0.00451
Part C: Interference	-0.4662	0.21732	0.41615	0.17318	0.07343	0.00539
TOL ^{DX}						
Total moves score	0.1657	0.02746	-0.333	0.1109	0.14156	0.02004
Total correct score	-0.1137	0.01292	0.32774	0.10741	-0.143	0.02046
Total initiation time score	0.09987	0.00997	0.08086	0.00654	-0.1566	0.02453
Total execution time score	0.34353	0.11801	-0.3261	0.10632	0.12278	0.01507
Total problem-solving time score	0.34317	0.11777	-0.2707	0.07326	0.06236	0.00389

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 3. Age-adjusted NEURONORMA scores (NSS_A) for age 50–56 (age range for norms = 50–60)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥93	≥308	≥680	≥730	≤24	≤21	≤6
3	1	—	92–83	307–273	679–622	729–710	25–43	22–32	7
4	2	—	82–75	272–174	621–509	709–677	44–55	33–42	8–11
5	3–5	—	74–63	173–134	508–452	676–547	56–60	43–46	12–19
6	6–10	—	62–54	133–104	451–372	546–481	61–71	47–48	20–21
7	11–18	1	53–48	103–83	371–349	480–414	72–79	49–55	22–25
8	19–28	2	47–42	82–71	348–317	413–368	80–88	56–58	26–31
9	29–40	—	41–34	70–54	316–267	367–334	89–96	59–61	32–33
10	41–59	3–4	33–24	53–42	266–222	333–276	97–100	62–69	34–39
11	60–71	5	23–19	41–35	221–176	275–240	101–107	70–74	40–41
12	72–81	—	18–14	34–30	175–157	239–206	108–112	75–78	42–46
13	82–89	6	13–11	29–21	156–139	205–190	113–119	79–81	47–50
14	90–94	7	10–6	20–15	138–125	189–171	120–123	82–86	51–54
15	95–97	—	5–4	14–13	124–115	170–147	124–126	87–93	55–56
16	98	8	—	12–11	114–100	146–127	127–130	94–98	57–66
17	99	9	3	10	99–93	126–110	—	99–100	67–72
18	>99	10	2–0	9–0	≤92	≤109	≥131	≥101	≥73
Sample size		137	137	137	137	137	136	136	136

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 4. Age-adjusted NEURONORMA scores (NSS_A) for age 57–59 (age range for norms = 53–63)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥93	≥308	≥680	≥730	≤43	≤32	≤6
3	1	—	92–83	307–273	679–622	729–695	—	33–36	7
4	2	—	82–80	272–223	621–524	694–677	44–46	—	8–11
5	3–5	—	79–63	222–127	523–483	676–552	47–64	37–45	12–18
6	6–10	—	62–54	126–103	482–416	551–513	65–68	46–48	19–20
7	11–18	1	53–48	102–81	415–357	512–419	69–79	49–51	21–25
8	19–28	2	47–41	80–66	356–320	418–373	80–86	52–57	26–29
9	29–40	—	40–35	65–55	319–267	372–329	87–93	58–60	30–32
10	41–59	3	34–27	54–42	266–234	328–283	94–99	61–67	33–38
11	60–71	4	26–22	41–35	233–199	282–256	100–105	68–74	39–41
12	72–81	5	21–17	34–32	198–173	255–226	106–110	75–78	42–44
13	82–89	6	16–14	31–26	172–156	225–202	111–119	79	45–49
14	90–94	—	13–11	25–17	155–137	201–192	120–123	80–85	50–54
15	95–97	7	10–6	16–14	136–128	191–187	124–126	86–90	55–56
16	98	—	5	13–12	127–125	186–182	127–130	91–93	57–66
17	99	8	4	11–9	124–115	181–147	—	94–98	67–72
18	>99	9–10	3–0	8–0	≤114	≤146	≥131	≥99	≥73
Sample size		133	133	133	133	133	133	133	133

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

(1996), the obtained NSS_A score was adjusted by the difference between the predicted scores based on the subject's actual education and the predicted score given 12 years of education. The obtained value was truncated to the next lower integer (e.g., 10.75 would be truncated to 10).

Results

Age distribution of the sample made it possible to calculate norms for 10 mid-point age groups. Sample sizes resulting from mid-point age intervals are presented in normative tables.

Table 5. Age-adjusted NEURONORMA scores (NSS_A) for age 60–62 (age range for norms = 56–66)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥93	≥415	≥740	≥784	≤42	≤20	≤6
3	1	—	92–83	414–308	739–680	783–730	43	21–32	7
4	2	—	82–80	307–223	679–622	729–695	—	33–36	8–9
5	3–5	—	79–64	222–127	621–483	694–563	44–55	37–40	10–18
6	6–10	—	63–57	126–109	482–431	562–529	56–66	41–46	19–20
7	11–18	1	56–49	108–84	430–369	528–445	67–73	47–49	21–24
8	19–28	2	48–42	83–66	368–331	444–378	74–80	50–54	25–26
9	29–40	—	41–36	65–54	330–277	377–331	81–90	55–58	27–30
10	41–59	3	35–27	53–41	276–234	330–286	91–99	59–65	31–36
11	60–71	4	26–22	40–35	233–199	285–256	100–104	66–70	37–41
12	72–81	5	21–18	34–31	198–174	255–213	105–110	71–76	42–43
13	82–89	—	17–14	30–26	173–154	212–202	111–119	77–79	44–47
14	90–94	6	13–11	25–20	153–144	201–190	120–123	80–82	48–50
15	95–97	—	10–9	19–15	143–128	189–172	124–126	83–86	51–55
16	98	7	8–6	14	127	171–154	127–130	87–89	—
17	99	—	5	13–12	126–125	153–147	—	90	56
18	>99	8–10	4–0	11–0	≤124	≤146	≥131	≥91	≥57
Sample size		124	124	124	124	124	123	123	123

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 6. Age-adjusted NEURONORMA scores (NSS_A) for age 63–65 (age range for norms = 59–69)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥104	≥415	≥742	≥838	≤42	≤20	≤6
3	1	—	103–93	414–223	741–740	837–784	43	21–32	7
4	2	—	92–73	222–193	739–680	783–730	44–45	33–36	8–9
5	3–5	—	72–63	192–123	679–515	729–565	46–53	37–40	10–13
6	6–10	—	62–61	122–109	514–460	564–538	54–60	41–42	14–15
7	11–18	1	60–50	108–81	459–382	537–459	61–70	43–47	16–21
8	19–28	2	49–46	80–66	381–341	458–413	71–76	48–49	22–24
9	29–40	—	45–37	65–54	340–281	412–344	77–84	50–56	25–28
10	41–59	3	36–28	53–44	280–244	343–308	85–97	57–62	29–34
11	60–71	4	27–24	43–37	243–215	307–276	98–99	63–68	35–38
12	72–81	5	23–19	36–32	214–182	275–244	100–103	69–74	39–41
13	82–89	6	18–14	31–28	181–169	243–207	104–114	75–78	42–45
14	90–94	—	13–11	27–22	168–150	206–191	115–120	79	46–49
15	95–97	7	10–7	21–18	149–130	190–172	121–124	80–82	50–53
16	98	—	6	—	129–128	171–154	125–130	83–84	54
17	99	—	5	17–16	127	153–147	—	85–90	55
18	>99	8–10	4–0	≤15	≤126	≤146	≥131	≥91	≥56
Sample size		106	106	106	106	106	106	106	106

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Correlations (Pearson's, r) and shared variance (determination coefficient, r^2) of SCWT and TOL^{DX} scores with age (years), education (years), and sex are presented in Table 2.

Age and education accounted significantly for the RS variance of the SWCT (age: 10%–22%; education: 17%–27%). Education effect is specifically reflected in the reading part of the test (27% of the shared variance). Sex differences were not observed, indicating no need to control this demographic variable.

Education accounted significantly for the RS variance of TOL^{DX} variables except for the total initiation time score. Conversely, age showed a minor effect on these variables ($\leq 2\%$). Sex also showed a minimal effect (2%). Concerning

Table 7. Age-adjusted NEURONORMA scores (NSS_A) for age 66–68 (age range for norms = 62–72)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥104	≥415	≥742	≥838	≤30	≤20	≤5
3	1	—	103–74	414–270	741–740	837–832	31–42	21–23	—
4	2	—	73	269–260	739–671	831–784	43–45	24–26	6–9
5	3–5	—	72–63	259–184	670–524	783–630	46–57	27–38	10–13
6	6–10	—	62–57	183–115	523–463	629–559	58–65	39–40	14–17
7	11–18	1	56–49	114–96	462–396	558–479	66–71	41–45	18–21
8	19–28	2	48–42	95–80	395–354	478–434	72–77	46–49	22–24
9	29–40	—	41–36	79–66	353–310	433–377	78–82	50–53	25–26
10	41–59	3–4	35–27	65–48	309–243	376–319	83–91	54–59	27–30
11	60–71	—	26–21	47–42	242–214	318–267	92–98	60–62	31–35
12	72–81	5	20–17	41–32	213–180	266–242	99–108	63–67	36–39
13	82–89	6	16–14	31–28	179–169	241–205	109–115	68–73	40–43
14	90–94	—	13–10	27–24	168–153	204–191	116–120	74–76	44–47
15	95–97	7	9–7	23–18	152–135	190–184	121–124	77–79	48–50
16	98	—	—	—	134–130	183–172	125–130	80–82	51
17	99	—	6	17–16	129–127	171–154	—	83–84	52–54
18	>99	8–10	5–0	≤15	≤126	≤153	≥131	≥85	≥55
Sample size		120	120	120	120	120	119	119	119≤≤

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 8. Age-adjusted NEURONORMA scores (NSS_A) for age 69–71 (age range for norms = 65–75)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥104	≥270	≥793	≥876	≤23	≤21	≤5
3	1	—	103–93	269–260	792–742	875–838	24–30	—	—
4	2	—	92–77	259–226	741–740	837–832	31–32	22–23	6–9
5	3–5	—	76–69	225–184	739–623	831–736	33–53	24–32	10–11
6	6–10	—	68–61	183–110	622–519	735–591	54–59	33–38	12–14
7	11–18	1	60–51	109–94	518–452	590–541	60–70	39–43	15–19
8	19–28	2	50–45	93–80	451–372	540–459	71–73	44–47	20–23
9	29–40	—	44–38	79–66	371–335	458–407	74–79	48–50	24–25
10	41–59	3–4	37–29	65–49	334–268	406–329	80–90	51–56	26–29
11	60–71	—	28–23	48–43	267–216	328–277	91–96	57–60	30–33
12	72–81	5	22–18	42–37	215–181	276–242	97–98	61–63	34–36
13	82–89	6	17–14	36–30	180–171	241–205	99–106	64–70	37–42
14	90–94	—	13–10	29–24	170–153	204–191	107–112	71–74	43–44
15	95–97	7	9–7	23–22	152–135	190–184	113–115	75–76	45–46
16	98	—	—	21–18	134–130	183–172	116–120	77	47–50
17	99	—	6	—	129–127	171–154	121–130	78–82	51
18	>99	8–10	5–0	≤17	≤126	≤153	≥131	≥83	≥52
Sample size		125	125	125	125	125	124	124	124≤

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

time scores, initiation time is independent of age, education, and sex. Total execution time score and total problem-solving time score showed a similar discrete effect (up to 11%) for both age and education.

Age-adjusted NEURONORMA scaled scores (NSS_A) for the TOL^{DX} and SCWT are presented in Tables 3–12. These tables include percentile ranks, ranges of ages contributing to each normative subsample, and the number of participants contributing to each test's normative estimates. To use the table, select the appropriate column corresponding to the patient's age, find the patient's RS, and subsequently refer to the corresponding NSS_A and percentile rank (left part of the table).

Table 9. Age-adjusted NEURONORMA scores (NSS_A) for age 72–74 (age range for norms = 68–78)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥104	≥270	≥793	≥876	≤23	≤21	≤5
3	1	—	103–93	269–260	792–742	875–838	24–30	—	6–8
4	2	—	92–79	259–226	741–725	837–832	31–32	22–23	—
5	3–5	—	78–72	225–184	724–623	831–736	33–47	24–29	9–10
6	6–10	—	71–61	183–116	622–550	735–641	48–59	30–36	11–13
7	11–18	1	60–51	115–94	549–483	640–562	60–67	37–40	14–17
8	19–28	2	50–45	93–79	482–410	561–481	68–75	41–45	18–20
9	29–40	—	44–39	78–66	409–350	480–433	76–81	46–49	21–24
10	41–59	3	38–32	65–51	349–274	432–335	82–89	50–55	25–27
11	60–71	4	31–26	50–45	273–239	334–298	90–95	56–60	28–30
12	72–81	5	25–20	44–40	238–203	297–257	96–98	61–62	31–36
13	82–89	6	19–16	39–31	202–180	256–230	99–104	63–67	37–40
14	90–94	—	15–11	30–25	179–171	229–203	105–111	68–71	41–44
15	95–97	7	10–8	24–22	170–160	202–192	112–114	72–76	45–46
16	98	—	7	—	159–158	191–189	115–120	77	—
17	99	8	—	21–18	157–152	188–186	121–123	78–82	47–50
18	>99	9–10	6–0	≤17	≤151	≤185	≥124	≥83	≥51
Sample size		126	126	126	126	126	124	124	124

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 10. Age-adjusted NEURONORMA scores (NSS_A) for age 75–77 (age range for norms = 71–81)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥93	≥260	≥793	≥876	≤22	≤20	≤4
3	1	—	92–79	259–226	792–725	875–832	23	—	5
4	2	—	78	225–221	724–697	831–767	24–30	21	6–8
5	3–5	—	77–69	220–166	696–623	766–736	31–41	22–27	9
6	6–10	—	68–59	165–109	622–571	735–641	42–54	28–32	10–11
7	11–18	1	58–50	108–94	570–506	640–579	55–61	33–39	12–15
8	19–28	—	49–45	93–80	505–443	578–498	62–70	40–45	16–18
9	29–40	2	44–40	79–67	442–354	497–443	71–77	46–48	19–21
10	41–59	3	39–31	68–53	353–288	442–354	78–85	49–54	22–26
11	60–71	4	30–26	52–43	287–251	353–311	86–91	55–57	27–28
12	72–81	5	25–20	42–39	250–214	310–261	92–96	58–60	29–34
13	82–89	6	19–14	38–33	213–186	260–239	97–100	61–66	35–38
14	90–94	—	13–12	32–29	185–172	238–216	101–109	67–69	39–43
15	95–97	7	11–8	28–24	171–166	215–196	110–114	70–73	44
16	98	—	7	23–22	165–160	195–186	115–119	74	45
17	99	8	—	21–18	159–144	185–184	120	75–77	—
18	>99	9–10	6–0	≤17	≤183	≤184	≥121	≥78	≥46
Sample size		102	102	102	102	102	98	98	98

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

As expected, the normative adjustments (NSS_A) eliminated the shared variance of age (Table 13). Education, however, continued to account for up to 11%–23% of shared variance with age-adjusted test scores for the SCWT, and up to 10% for the TOL^{DX}. To maintain the same analysis, education adjustments were applied to all variables, although the effect was minor in total initiation time and total problem-solving time scores.

The transformation of RS to NSS_A produced a normalized distribution on which linear regressions could be applied. Regression coefficients from this analysis were used as the basis for education (years) adjustments. From these data, we have constructed adjustment tables to help the clinician make the necessary adjustment (Tables 14–16 for the SCWT, and Tables 17–21 for the TOL^{DX}). These tables include the respective values of β for every variable.

Table 11. Age-adjusted NEURONORMA scores (NSS_A) for age 78–80 (age range for norms = 74–84)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥94	≥227	≥794	≥877	≤31	≤20	≤7
3	1	—	93	226	793	876	32	21	8
4	2	—	—	—	—	—	—	—	—
5	3–5	—	92–78	225–166	792–697	875–736	33–41	22–27	9
6	6–10	1	77–61	165–116	696–595	735–662	42–50	28–32	10–11
7	11–18	—	60–50	115–98	594–510	661–601	51–55	33–35	12–14
8	19–28	—	49–43	97–83	509–473	600–541	56–67	36–40	15–17
9	29–40	2	42–40	80–73	472–407	540–481	68–75	41–46	18–19
10	41–59	3	39–32	72–60	406–301	480–392	76–83	47–51	20–23
11	60–71	4	31–26	59–51	300–272	391–330	84–89	52–54	24–26
12	72–81	—	25–22	50–42	271–251	329–306	90–97	55–60	27–31
13	82–89	5–6	21–16	41–34	250–214	305–256	98–100	61–64	32–36
14	90–94	—	15–13	33–30	213–189	255–230	101–104	65–68	37–38
15	95–97	—	12–9	29	188–172	229–218	105–114	69	39–40
16	98	7	8–7	28–26	171–144	217–186	115–119	70–71	41–42
17	99	—	—	—	—	—	—	—	—
18	>99	8–10	6–0	≤25	≤143	≤185	≥120	≥72	≥43
Sample size		66	66	66	66	66	65	65	65

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 12. Age-adjusted NEURONORMA scores (NSS_A) for age 81–90 (age range for norms = 77–90)

Scaled score	Percentile range	TOL ^{DX}					SCWT		
		Total correct score	Total move score	Total initiation time	Total execution time	Total problem-solving time	Word score	Color score	Word-color score
2	<1	0	≥103	≥222	≥874	≥968	≤20	≤17	≤7
3	1	—	—	—	—	—	—	—	—
4	2	—	102	221	873	967	21	18	8
5	3–5	—	101–79	220–140	872–709	966–782	22–41	19–21	9
6	6–10	1	78–77	139–118	708–600	781–711	42–50	22–32	10
7	11–18	—	76–57	117–106	599–571	710–634	51–54	33–35	11–14
8	19–28	2	56–46	105–89	570–499	633–576	55–65	36–40	15–16
9	29–40	—	44–40	88–73	498–407	575–474	66–75	41–46	17–18
10	41–59	3	39–29	72–62	406–303	473–395	76–83	47–49	19–22
11	60–71	—	28–26	61–49	302–272	394–354	84–88	50–54	23–25
12	72–81	4–5	25–22	48–41	271–251	353–307	89–95	55–58	26–27
13	82–89	—	21–18	39–35	250–237	306–298	96–99	59–60	28–34
14	90–94	6	17–13	34–31	236–214	297–282	100–104	61–66	35–36
15	95–97	—	12–11	—	213–203	281–256	105–114	67–68	37
16	98	7	10–9	30	202–189	255–252	115–119	69–71	38–40
17	99	—	—	—	—	—	—	—	—
18	>99	8–10	7–0	≤29	≤188	≤251	≥120	≥72	≥41
Sample size		41	41	41	41	41	41	41	41

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

To use the tables, select the appropriate column corresponding to the patient's years of education, find the patient's NSS_A, and subsequently refer to the corresponding NSS_{A&E}. When these formulas were applied to the NEURONORMA sample, the shared variances between demographically adjusted NEURONORMA scaled scores and years of education fell to <1%.

Discussion

The objective of this paper was to provide normative data for older Spaniards on the SWCT and the TOL^{DX}. The normative data presented here were obtained from the same study samples as all the other NEURONORMA tests. This is a co-norming study that follows the basic model of the MOANS project.

Table 13. Correlations (r) and shared variances (r^2) of NEURONORMA subtest scores with age and years of education

Measure	Age (years)		Education (years)	
	r	r^2	r	r^2
<i>SCWT</i>				
Part A: Word	-0.038	0.00144	0.48876	0.23889
Part B: Color	-0.057	0.00325	0.40354	0.16284
Part C: Interference	-0.066	0.00436	0.34169	0.11675
<i>TOL^{DX}</i>				
Total moves score	-0.0112	0.00013	0.31929	0.10195
Total correct score	-0.0097	0.00009	0.30246	0.09148
Total initiation time score	-0.0144	0.00021	-0.122	0.01487
Total execution time score	-0.0356	0.00126	0.29159	0.08502
Total problem-solving time score	-0.0344	0.00118	0.22066	0.04869

Note: SCWT = Stroop color-word interference test; TOL^{DX} = Tower of London-Drexel University version.

Table 14. Stroop color-word interference test part A (word)

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	5	4	4	4	4	3	3	3	3	2	2	2	2	1	1	1	0	0	0	0	-1
3	6	5	5	5	5	4	4	4	4	3	3	3	3	2	2	2	1	1	1	1	0
4	7	6	6	6	6	5	5	5	5	4	4	4	4	3	3	3	2	2	2	2	1
5	8	7	7	7	7	6	6	6	6	5	5	5	5	4	4	4	3	3	3	3	2
6	9	8	8	8	8	7	7	7	7	6	6	6	6	5	5	5	4	4	4	4	3
7	10	9	9	9	9	8	8	8	8	7	7	7	7	6	6	6	5	5	5	5	4
8	11	10	10	10	10	9	9	9	9	8	8	8	8	7	7	7	6	6	6	6	5
9	12	11	11	11	11	10	10	10	10	9	9	9	9	8	8	8	7	7	7	7	6
10	13	12	12	12	12	11	11	11	11	10	10	10	10	9	9	9	8	8	8	8	7
11	14	13	13	13	13	12	12	12	12	11	11	11	11	10	10	10	9	9	9	9	8
12	15	14	14	14	14	13	13	13	13	12	12	12	12	11	11	11	10	10	10	10	9
13	16	15	15	15	15	14	14	14	14	13	13	13	13	12	12	12	11	11	11	11	10
14	17	16	16	16	16	15	15	15	15	14	14	14	14	13	13	13	12	12	12	12	11
15	18	17	17	17	17	16	16	16	16	15	15	15	15	14	14	14	13	13	13	13	12
16	19	18	18	18	18	17	17	17	17	16	16	16	16	15	15	15	14	14	14	14	13
17	20	19	19	19	19	18	18	18	18	17	17	17	17	16	16	16	15	15	15	15	14
18	21	20	20	20	20	19	19	19	19	18	18	18	18	17	17	17	16	16	16	16	15

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.25663$.

Stroop Color-Word Interference Test

The pattern of the socio-demographic effects obtained in our study is similar in part to the most normative data published by others. That is to say, the impact of age and education has been clearly found in the three conditions of the test, producing a slowing in color naming and a clear increase in the interference task (e.g., Anstey et al., 2000; Cohn et al., 1984; Graf et al., 1995; Ivnik et al., 1996; Lucas et al., 2005; Moering et al., 2004; Troyer et al., 2006; Van der Elst et al., 2006). Moreover, as other investigations reported earlier (Anstey et al., 2000; Ivnik et al., 1996), we have not found a significant influence of sex on the performance in all the conditions of SCWT. Our results are very similar to that obtained by Ivnik and colleagues (1996) and Lucas and colleagues (2005) in MOANS and MOAANS projects. Owing to sample characteristics, methodological, and statistical differences it is difficult to compare present data with previous studies on Spanish speaking subjects cited in the introduction section.

Tower of London-Drexel University version

In our study, age and education influenced performance in most variables of the TOL^{DX} (Table 2). Sex did not have a significant impact on the scores of the test. Our study includes considerably more subjects in the older age range than the normative sample presented in the technical manual of the TOL^{DX} (Culbertson & Zillmer, 2001). However, it is relevant that when

Table 15. Stroop color-word interference test part B (color)

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	4	4	4	3	3	3	3	3	2	2	2	2	2	1	1	1	1	0	0	0	0
3	5	5	5	4	4	4	4	4	3	3	3	3	3	2	2	2	2	1	1	1	1
4	6	6	6	5	5	5	5	5	4	4	4	4	4	3	3	3	3	2	2	2	2
5	7	7	7	6	6	6	6	6	5	5	5	5	5	4	4	4	4	3	3	3	3
6	8	8	8	7	7	7	7	7	6	6	6	6	6	5	5	5	5	4	4	4	4
7	9	9	9	8	8	8	8	8	7	7	7	7	7	6	6	6	6	5	5	5	5
8	10	10	10	9	9	9	9	9	8	8	8	8	8	7	7	7	7	6	6	6	6
9	11	11	11	10	10	10	10	10	9	9	9	9	9	8	8	8	8	7	7	7	7
10	12	12	12	11	11	11	11	11	10	10	10	10	10	9	9	9	9	8	8	8	8
11	13	13	13	12	12	12	12	12	11	11	11	11	11	10	10	10	10	9	9	9	9
12	14	14	14	13	13	13	13	13	12	12	12	12	12	11	11	11	11	10	10	10	10
13	15	15	15	14	14	14	14	14	13	13	13	13	13	12	12	12	12	11	11	11	11
14	16	16	16	15	15	15	15	15	14	14	14	14	14	13	13	13	13	12	12	12	12
15	17	17	17	16	16	16	16	16	15	15	15	15	15	14	14	14	14	13	13	13	13
16	18	18	18	17	17	17	17	17	16	16	16	16	16	15	15	15	15	14	14	14	14
17	19	19	19	18	18	18	18	18	17	17	17	17	17	16	16	16	16	15	15	15	15
18	20	20	20	19	19	19	19	19	18	18	18	18	18	17	17	17	17	16	16	16	16

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.2099$.

Table 16. Stroop color-word interference test part C (interference)

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	4	3	3	3	3	3	3	2	2	2	2	2	2	1	1	1	1	1	0	0	0
3	5	4	4	4	4	4	4	3	3	3	3	3	3	2	2	2	2	2	1	1	1
4	6	5	5	5	5	5	5	4	4	4	4	4	4	3	3	3	3	3	2	2	2
5	7	6	6	6	6	6	6	5	5	5	5	5	5	4	4	4	4	4	3	3	3
6	8	7	7	7	7	7	7	6	6	6	6	6	6	5	5	5	5	5	4	4	4
7	9	8	8	8	8	8	8	7	7	7	7	7	7	6	6	6	6	6	5	5	5
8	10	9	9	9	9	9	9	8	8	8	8	8	8	7	7	7	7	7	6	6	6
9	11	10	10	10	10	10	10	9	9	9	9	9	9	8	8	8	8	8	7	7	7
10	12	11	11	11	11	11	11	10	10	10	10	10	10	9	9	9	9	9	8	8	8
11	13	12	12	12	12	12	12	11	11	11	11	11	11	10	10	10	10	10	9	9	9
12	14	13	13	13	13	13	13	12	12	12	12	12	12	11	11	11	11	11	10	10	10
13	15	14	14	14	14	14	14	13	13	13	13	13	13	12	12	12	12	12	11	11	11
14	16	15	15	15	15	15	15	14	14	14	14	14	14	13	13	13	13	13	12	12	12
15	17	16	16	16	16	16	16	15	15	15	15	15	15	14	14	14	14	14	13	13	13
16	18	17	17	17	17	17	17	16	16	16	16	16	16	15	15	15	15	15	14	14	14
17	19	18	18	18	18	18	18	17	17	17	17	17	17	16	16	16	16	16	15	15	15
18	20	19	19	19	19	19	19	18	18	18	18	18	18	17	17	17	17	17	16	16	16

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.17826$.

comparing the central tendency (scaled score 100 for 49–59 and 60+ year old subjects) of the norms presented in the manual with our data (NSS_A of 10), similar results were obtained. A total correct RS of 3–4 (corresponding to an NSS_A of 10) is observed in all NEURONORMA mid-point groups (Tables 4–12) and roughly corresponds to a scaled score of 100 in the American norms. When education adjustments are applied to total moves score NSS_A, the final NSS_{A&E} could be 8–9 for higher (13–20 years) educated subjects and 11 for the lower (0–5 years) educated subjects. For subjects with an intermediate education (6–12 years), NSS_{A&E} remains the same (10). Total move scores of the American norms are also similar to ours. In the American norms, a scaled score of 100 corresponds to an RS of 30–32 for 40–59-year-old subjects and to an RS of 39–40 for 60+-year-old subjects. Similarly, in the NEURONORMA project, an RS of 30–32 corresponds to an NSS_A of 10–11, and an RS of 39–40 corresponds to an NSS_A of 9–10. Time scores (initiation time, total execution time, and total problem-solving time) show the same similar pattern of central tendencies. In our study, education allows a further adjustment of age-corrected RS.

Table 17. Tower of London^{DX}: Total moves score

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0
3	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1
4	5	5	5	5	5	5	4	4	4	4	4	4	4	3	3	3	3	3	3	2	2
5	6	6	6	6	6	6	5	5	5	5	5	5	5	4	4	4	4	4	4	3	3
6	7	7	7	7	7	7	6	6	6	6	6	6	6	5	5	5	5	5	5	4	4
7	8	8	8	8	8	8	7	7	7	7	7	7	7	6	6	6	6	6	6	5	5
8	9	9	9	9	9	9	8	8	8	8	8	8	8	7	7	7	7	7	7	6	6
9	10	10	10	10	10	10	9	9	9	9	9	9	9	8	8	8	8	8	8	7	7
10	11	11	11	11	11	11	10	10	10	10	10	10	10	9	9	9	9	9	9	8	8
11	12	12	12	12	12	12	11	11	11	11	11	11	11	10	10	10	10	10	10	9	9
12	13	13	13	13	13	13	12	12	12	12	12	12	12	11	11	11	11	11	11	10	10
13	14	14	14	14	14	14	13	13	13	13	13	13	13	12	12	12	12	12	12	11	11
14	15	15	15	15	15	15	14	14	14	14	14	14	14	13	13	13	13	13	13	12	12
15	16	16	16	16	16	16	15	15	15	15	15	15	15	14	14	14	14	14	14	13	13
16	17	17	17	17	17	17	16	16	16	16	16	16	16	15	15	15	15	15	15	14	14
17	18	18	18	18	18	18	17	17	17	17	17	17	17	16	16	16	16	16	16	15	15
18	19	19	19	19	19	19	18	18	18	18	18	18	18	17	17	17	17	17	17	16	16

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.16314$.

Table 18. Tower of London^{DX}: Total correct score

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0
3	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1
4	5	5	5	5	5	5	4	4	4	4	4	4	4	3	3	3	3	3	3	2	2
5	6	6	6	6	6	6	5	5	5	5	5	5	5	4	4	4	4	4	4	3	3
6	7	7	7	7	7	7	6	6	6	6	6	6	6	5	5	5	5	5	5	4	4
7	8	8	8	8	8	8	7	7	7	7	7	7	7	6	6	6	6	6	6	5	5
8	9	9	9	9	9	9	8	8	8	8	8	8	8	7	7	7	7	7	7	6	6
9	10	10	10	10	10	10	9	9	9	9	9	9	9	8	8	8	8	8	8	7	7
10	11	11	11	11	11	11	10	10	10	10	10	10	10	9	9	9	9	9	9	8	8
11	12	12	12	12	12	12	11	11	11	11	11	11	11	10	10	10	10	10	10	9	9
12	13	13	13	13	13	13	12	12	12	12	12	12	12	11	11	11	11	11	11	10	10
13	14	14	14	14	14	14	13	13	13	13	13	13	13	12	12	12	12	12	12	11	11
14	15	15	15	15	15	15	14	14	14	14	14	14	14	13	13	13	13	13	13	12	12
15	16	16	16	16	16	16	15	15	15	15	15	15	15	14	14	14	14	14	14	13	13
16	17	17	17	17	17	17	16	16	16	16	16	16	16	15	15	15	15	15	15	14	14
17	18	18	18	18	18	18	17	17	17	17	17	17	17	16	16	16	16	16	16	15	15
18	19	19	19	19	19	19	18	18	18	18	18	18	18	17	17	17	17	17	17	16	16

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.15447$.

Considering that the TOL^{DX} depends on various processes such as perceptual, conceptual, working memory, or executive (Newman et al., 2003), the interpretation of abnormal scores should be carried out with caution. Future NEURONORMA studies should focus on the correlations of the variables of the SCWT and the TOL^{DX} with other tests of the project, especially with working memory measures (Zook et al., 2004).

General Discussion

To help clinicians, NSS_A were adjusted to NSS_{A&E} using tables resulting from the application of computational formulas. In these tables, figures were rounded to an integer. In some cases, the resulting adjustment may be placed beyond the defined scaled score ranges (e.g., 21 or -1). In these extreme cases, the final score should be 18 or 2, respectively. It would not be

Table 19. Tower of London^{DX}: Total time score

SSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	1	1
3	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2
4	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	3	3	3
5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4	4	4	4	4
6	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5	5	5	5	5
7	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	6
8	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	7	7	7	7	7
9	9	9	9	9	9	9	9	9	9	8	8	8	8	8	8	8	8	8	8	8	8
10	10	10	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9	9	9	9	9
11	11	11	11	11	11	11	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10
12	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11	11
13	13	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12
14	14	14	14	14	14	14	14	14	14	13	13	13	13	13	13	13	13	13	13	13	13
15	15	15	15	15	15	15	15	15	15	14	14	14	14	14	14	14	14	14	14	14	14
16	16	16	16	16	16	16	16	16	16	15	15	15	15	15	15	15	15	15	15	15	15
17	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	16	16	16	16	16
18	18	18	18	18	18	18	18	18	18	17	17	17	17	17	17	17	17	17	17	17	17

Note: Education adjustment applying the following formula: $NSS_{AE} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = -0.06256$.

Table 20. Tower of London^{DX}: Total execution time score

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	3	3	3	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	0	0
3	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	2	2	2	1	1
4	5	5	5	5	5	5	4	4	4	4	4	4	4	3	3	3	3	3	3	2	2
5	6	6	6	6	6	6	5	5	5	5	5	5	5	4	4	4	4	4	4	3	3
6	7	7	7	7	7	7	6	6	6	6	6	6	6	5	5	5	5	5	5	4	4
7	8	8	8	8	8	8	7	7	7	7	7	7	7	6	6	6	6	6	6	5	5
8	9	9	9	9	9	9	8	8	8	8	8	8	8	7	7	7	7	7	7	6	6
9	10	10	10	10	10	10	9	9	9	9	9	9	9	8	8	8	8	8	8	7	7
10	11	11	11	11	11	11	10	10	10	10	10	10	10	9	9	9	9	9	9	8	8
11	12	12	12	12	12	12	11	11	11	11	11	11	11	10	10	10	10	10	10	9	9
12	13	13	13	13	13	13	12	12	12	12	12	12	12	11	11	11	11	11	11	10	10
13	14	14	14	14	14	14	13	13	13	13	13	13	13	12	12	12	12	12	12	11	11
14	15	15	15	15	15	15	14	14	14	14	14	14	14	13	13	13	13	13	13	12	12
15	16	16	16	16	16	16	15	15	15	15	15	15	15	14	14	14	14	14	14	13	13
16	17	17	17	17	17	17	16	16	16	16	16	16	16	15	15	15	15	15	15	14	14
17	18	18	18	18	18	18	17	17	17	17	17	17	17	16	16	16	16	16	16	15	15
18	19	19	19	19	19	19	18	18	18	18	18	18	18	17	17	17	17	17	17	16	16

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.15080$.

accurate to apply these computational formulas to younger individuals due to the different impact of the demographic variables on the cognitive performance across the life span (e.g., Lucas et al., 2005).

The validity of these normative data is related to the similarity between the characteristics of the specifically studied subject and the demographic features of the normative sample. Present norms provide a useful resource for clinical studies in a Spanish population. The general limitations of NEURONORMA norms have been discussed in a previous paper (Peña-Casanova et al., 2009) and are mainly related to the selection of the participants (limited representation of extremely elderly participants and a convenience sample of community volunteers). Despite these limitations, this paper presents the largest normative study to date for neuropsychological performance in older Spanish subjects on the SWCT and on the TOL^{DX}.

Table 21. Tower of London^{DX}: Total problem-solving time score

NSS _A	Education (years)																				
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2	3	3	3	3	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1
3	4	4	4	4	3	3	3	3	3	3	3	3	3	2	2	2	2	2	2	2	2
4	5	5	5	5	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3
5	6	6	6	6	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	4	4
6	7	7	7	7	6	6	6	6	6	6	6	6	6	5	5	5	5	5	5	5	5
7	8	8	8	8	7	7	7	7	7	7	7	7	7	6	6	6	6	6	6	6	6
8	9	9	9	9	8	8	8	8	8	8	8	8	8	7	7	7	7	7	7	7	7
9	10	10	10	10	9	9	9	9	9	9	9	9	9	8	8	8	8	8	8	8	8
10	11	11	11	11	10	10	10	10	10	10	10	10	10	9	9	9	9	9	9	9	9
11	12	12	12	12	11	11	11	11	11	11	11	11	11	10	10	10	10	10	10	10	10
12	13	13	13	13	12	12	12	12	12	12	12	12	12	11	11	11	11	11	11	11	11
13	14	14	14	14	13	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12
14	15	15	15	15	14	14	14	14	14	14	14	14	14	13	13	13	13	13	13	13	13
15	16	16	16	16	15	15	15	15	15	15	15	15	15	14	14	14	14	14	14	14	14
16	17	17	17	17	16	16	16	16	16	16	16	16	16	15	15	15	15	15	15	15	15
17	18	18	18	18	17	17	17	17	17	17	17	17	17	16	16	16	16	16	16	16	16
18	19	19	19	19	18	18	18	18	18	18	18	18	18	17	17	17	17	17	17	17	17

Note: Education adjustment applying the following formula: $NSS_{A\&E} = NSS_A - (\beta \times [Education_{(years)} - 12])$, where $\beta = 0.11423$.

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Conflict of Interest

None declared.

Appendix

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