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Spanish Multicenter Normative Studies (Neuronorma Project): Norms for the Abbreviated Barcelona Test

María Quintana[1], Jordi Peña-Casanova[1,2,*], Gonzalo Sánchez-Benavides[1], Klaus Langohr[3], Rosa M. Manero[2], Miguel Aguilar[4], Dolors Badenes[4], José Luis Molinuevo[5], Alfredo Robles[6], María Sagrario Barquero[7,†], Carmen Antúnez[8], Carlos Martínez-Parra[9], Anna Frank-García[10], Manuel Fernández[11], Rafael Blesa[12], for the Neuronorma Study Team[‡]

[1]*Group of Behavioral Neurology, Neuropsychopharmacology Program, Institut Municipal d'Investigació Mèdica, Barcelona, Spain*
[2]*Section of Behavioral Neurology and Dementias, Hospital del Mar, Parc de Salut Mar, Barcelona, Spain*
[3]*Human Pharmacology and Clinical Neurosciences Research Group, Neuropsychopharmacology Program, Institut Municipal d'Investigació Mèdica, Barcelona, Spain*
[4]*Service of Neurology, Hospital Mútua de Terrassa, Terrassa, Spain*
[5]*Service of Neurology, Hospital Clínic, Barcelona, Spain*
[6]*Service of Neurology, Hospital Clínico Universitario, Santiago de Compostela, Spain*
[7]*Service of Neurology, Hospital Clínico San Carlos, Madrid, Spain*
[8]*Service of Neurology, Hospital Virgen Arrixaca, Murcia, Spain*
[9]*Service of Neurology, Hospital Virgen Macarena, Sevilla, Spain*
[10]*Department of Neurology, Hospital Universitario La Paz, Madrid, Spain*
[11]*Service of Neurology, Hospital de Cruces, Bilbao, Spain*
[12]*Service of Neurology, Hospital de la Santa Creu i Sant Pau, Barcelona, Spain*

*Corresponding author at: Institut Municipal d'Investigació Mèdica, Biomedical Research Park Building, Carrer Dr. Aiguader, 88, 08003 Barcelona, Spain. Tel.: +34-93-3160765; fax: +34-93-933160723.
E-mail address: jpcasanova@parcdesalutmar.cat (J. Peña-Casanova).

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Abstract

The abbreviated Barcelona Test (a-BT) is an instrument widely used in Spain and Latin American countries for general neuropsychological assessment. The purpose of the present study was to provide new norms for the a-BT as part of the Neuronorma project. The sample consisted of 346 healthy controls. Overlapping cell procedure and midpoint techniques were applied to develop the normative data. Age, education, and sex influences were studied. Results indicated that although age and education affected the score on this test, sex did not. Raw scores were transformed to age-adjusted scaled scores (SS_A) based on percentile ranks. These SS_A were also converted into age–education scaled scores using a linear regression model. Norms were presented on age–education scaled scores. Also, the a-BT cognitive profile was presented and should prove to be clinically useful for interpretation. These co-normed data will allow clinicians to compare scores from a-BT with all the tests included in the Neuronorma project.

Keywords: Norms/normative studies; Assessment; Elderly/geriatrics/aging

Introduction

The availability of appropriate normative data is critical to the quality of neuropsychological assessment. As a result, well-standardized tests should be chosen (Evans, 2003; Strauss, Sherman, & Spreen, 2006) because normative data are necessary for

† Deceased.
‡ Members of the Neuronorma Study Team are given in Appendix B.

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diagnostic and descriptive accuracy (Busch & Chapin, 2008). Several integrated neuropsychological batteries have been published with the objective of improving precision in diagnosis (Lezak, Howieson, & Loring, 2004).

The Barcelona Test (BT) is a neuropsychological battery that has been standardized and validated in a Spanish population (Peña-Casanova, 1990). It includes a series of subtests that cover a basic spectrum of the neuropsychological functions: language, orientation, attention, praxis, visual perceptual functions, memory, and executive functions. The abbreviated form (a-BT) was designed to evaluate cognitive deficits associated with brain damage. It deals with the most basic and sensitive neuropsychological items of the original and has a global standard score (Guardia et al., 1997; Peña-Casanova, Guardia, Bertran-Serra, Manero, & Jarne, 1997; Peña-Casanova, Meza, et al., 1997). It takes only 30–45 min to administer.

The norms for this test were published in 1997 (Peña-Casanova, Guardia, et al., 1997) and were based on a sample of 341 individuals, aged 20–80 years ($M = 54.80$ years, $SD = 17.44$). Five different groups concerning age and level of education were considered, resulting in five distinct cognitive profiles (Peña-Casanova, Guardia, et al., 1997).

The Revised BT was later published with an increased normative sample (Peña-Casanova, 2005). In addition, a number of studies have reported complementary normative data from several subtests of the a-BT. Cejudo-Bolívar, Torrealba-Fernández, Guardia-Olmos, and Peña-Casanova (1998) extended the normative information on the drawing task. Another study (García-Morales, Gigh-Fullà, Guardia-Olmos, & Peña-Casanova, 1998) analyzed the impact of age and education on orientation, digit span, and automatic speech. Gramunt-Fombuena, Cejudo-Bolívar, Serra-Mayoral, Guardia-Olmos, and Peña-Casanova (1998) published additional normative data for arithmetic, similarities, digit-symbol, and block design based on a sample of 264 individuals. There are also Latin American versions, such as the Mexican one (Villa, 1995), although it has not been published.

Clinically, the a-BT has been used to examine patients with mild cognitive impairment (Frutos-Alegría, Moltó-Jordà, Morera-Guitart, Sánchez-Pérez, & Ferrer-Navajas, 2007; Rami et al., 2007), Alzheimer's disease (Peña-Casanova et al., 2005), schizophrenia (Gil et al., 2008), amyotrophic lateral sclerosis (Duque et al., 2003), and toxic oil syndrome (De la Paz et al., 2003).

As to psychometric characteristics, this test has shown higher convergent validity with the Alzheimer Disease Assessment Scale-cognitive part (ADAS-Cog) (Peña-Casanova, Meza, et al., 1997), and excellent test–retest, and inter-rater reliability (Serra-Mayoral & Peña-Casanova, 2006).

Moreover, the global score of the a-BT correlates with functional scales (Peña-Casanova et al., 2005) such as the Rapid Disability Rating Scale-2 (Linn & Linn, 1982), the Blessed Dementia Rating Scale (Blessed, Tomlinson, & Roth, 1968), and the Interview for Deterioration of Daily living in Dementia (IDDD; Teunisse, Derix, & Cléber, 1991).

The a-BT was included in the Spanish Multicenter Normative Studies battery (Neuronorma battery) as a complement because it includes aspects that are not present in the series of tests normalized in that project. The Neuronorma project attempts to provide norms for commonly used neuropsychological tests in people aged over 49 years. The results of this project have been recently published (Peña-Casanova, Blesa, et al., 2009; Peña-Casanova, Gramunt-Fombuena, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Aguilar, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Quintana, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Quintana-Aparicio, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Quintana-Aparicio, et al., 2009; Peña-Casanova, Quintana-Aparicio, Quiñones-Úbeda, et al., 2009).

In this paper, we provide normative data for the a-BT in the context of the Neuronorma project.

Materials and Methods

Research Participants

Participants in this study included 356 healthy, older adults subjects. A detailed description of recruitment procedures, sample characteristics, and other aspects of the Neuronorma project has been provided by Peña-Casanova, Blesa, and colleagues, (2009). Briefly, participants were independently functioning, community-dwelling, and Spanish speakers aged over 49 with no active neurological/psychiatric disorders or current medical illness that could affect cognition.

Participants were recruited from a variety of sources such as: (1) spouses of patients evaluated at the participating centers; (2) different senior citizen activity centers; and (3) by word of mouth.

Ten participants did not complete the a-BT subtest and were excluded from the final analyses ($n = 346$). The sample included 140 men (40.5%) and 206 women (59.5%). The mean age was 65.04 ($SD = 9.38$) years, with a mean education of 10.56 years ($SD = 5.46$). The majority (97%) of study participants were right-handed. Descriptive demographic data for the sample are presented in Table 1. Additional demographic, sociocultural, and health-related characteristics of the normative

Table 1. Demographic characteristics of the sample

	n	Percent of total
Age group		
50–56	75	21.6
57–59	49	14.4
60–62	33	9.5
63–65	18	5.2
66–68	25	7.2
69–71	49	14.4
72–74	33	9.5
75–77	30	8.6
78–80	21	6.0
>80	13	3.7
Education (years)		
≤5	72	21.0
6–7	26	7.5
8–9	66	19.0
10–11	40	11.5
12–13	35	10.1
14–15	32	9.2
≥16	75	21.8
Sex		
Men	140	40.5
Women	206	59.5
Total sample	346	100

sample (family antecedents, personal antecedents, and active medical treatment) have been described in detail by Peña-Casanova, Blesa, and colleagues (2009).

Approval to conduct the study was obtained from the Research Ethics Committee of the Municipal Institute of Medical Care of Barcelona, Spain, and from the different participating centers. The study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 1997) and its subsequent amendments, and the European Union regulations concerning medical research. All participants signed an informed consent before being tested and they received no financial reimbursement or any other compensation.

Neuropsychological Measures

A global cognition measure, the Mini Mental Status Examination (Folstein, Folstein, & McHugh, 1975) in a Spanish validated version (Blesa et al., 2001), was used to select study participants. The age- and education-adjusted cutoff in the study was 24. Functional changes were evaluated by the IDDD (Teunisse et al., 1991) in its Spanish validated version (Böhm et al., 1998).

The a-BT was administered as part of a larger battery of neuropsychological measures in the Neuronorma project (Peña-Casanova, Blesa, et al., 2009). Testing and scoring were performed by neuropsychologists specifically trained for this project. All the onsite neuropsychologists were licensed as psychologists and highly experienced in neuropsychological test administration and diagnosis. Standard administration and scoring procedures were followed as outlined in the original a-BT manual (Peña-Casanova, 1990). It consists of 41 subtests that generate 55 variables which encompass a basic spectrum of the neuropsychological functions: language, attention, mental tracking, working memory, repetition, confrontation naming, semantic fluency, verbal comprehension, reading, writing, praxis, visual perceptual functions, verbal memory (story), visual memory (figures), numerical reasoning, concept formation, sustained attention, speed, and visuospatial and motor skills (details are shown in Appendix A).

In a series of subtests, a double score is included: a "pass or fail score" (one point scored for each item passed) and a "time score" (score adjusted to allow for delay in responding). Credit is only allowed for a correct response. The score may range from 1 to 3 for correct items depending on the time elapsed for responding.

Statistical Analysis

Normative procedures were the same as those used in the Neuronorma project (Peña-Casanova, Blesa, et al., 2009). To summarize, age groups were defined through the overlapping cell procedure described by Pauker (1988). The effect of age,

education, and sex on raw a-BT subtest scores was studied using coefficients of correlation (r) and determination (R^2). The a-BT subtest raw scores were converted to age-adjusted scaled scores (SS_A; from 2 to 18), SS_A based on percentile ranks, to produce a normal distribution (average 10, *SD* 3). Linear regressions were applied to the normalized SS_A on each variable to further adjust for education and derived age- and education-adjusted scaled scores (SS_{AE}).

The regression coefficient (β) from this analysis was taken as the basis for education adjustments, when β was significant value. The formula outlined by Mungas, Marshall, Weldon, Haan, and Reed (1996) employed to calculate SS_{AE} was the following:

$$SS_{AE} = SS_A - (\beta \times [\text{Education (years)} - 12])$$

In this linear regression, the criterion variable was the a-BT score and the predictor variable was years of education. This model can be applied due to the previously created normal distribution.

Statistical analyses were performed using R statistical software (v2.7.0) (R Development Core Team, 2008).

Results

Correlations (r) and shared variances (R^2) of all the subtests of the a-BT with age, education, and sex are presented in Table 2.

Age and education shared variance in the majority of the a-BT subtests. Sex differences accounted for $<2\%$ of shared variance in all subtests, except in arithmetic, indicating no need to control for this demographic variable.

It was not possible to calculate correlations and shared variances in several variables because all the subjects obtained the same value. For example, the variance was zero in the case of subtests such as language and grammar, or forward series.

For age, shared variance (R^2) ranged between minimal (e.g., $<1\%$ in personal orientation) and significant values (e.g., 24.8% in digit-symbol). A similar effect occurred in the case of education. The influence of this variable was significant in the majority of subtests, with high values as in visual memory ($R^2 = 30.8\%$), arithmetic ($R^2 = 39.3\%$), similarities ($R^2 = 40.6\%$), and digit-symbol ($R^2 = 43.5\%$).

As an example, Table 3 provides the conversion of the raw scores of the story (narrative fragment) free recall to SS_A. In this table are presented the percentile ranks, the age range of each midpoint (50–56, 57–59, 60–62, 63–65, 66–68, 69–71, 72–74, 75–77, 78–80, and 81+), the ranges of ages contributing to each normative group, and the number of participants contributing to each test normative estimate. The SS_A have a range from 2 to 18 and a normal distribution (a mean of 10 and an *SD* of 3). Due to the large number of subtests, the rest of the SS_A tables are presented as Supplementary material 1.

Table 4 provides the conversion of SS_A to SS_{AE} for the same previously presented subtest, the story (narrative fragment) free recall. To use this table, select the appropriated column corresponding to the patient's years of education, find the patient's SS_A, and subsequently refer to the corresponding SS_{AE}. See Supplementary material 2 for the other subtests of the a-BT.

We observed that some subtests show a very skewed distribution. In these special subtests, a single item failure represents impairment. These subsets are presented in Table 5. If the subject obtains the maxim score, the SS_A is 18, but if the subject makes a mistake in such case, the SS_A is 2. The same pattern was observed in all age range of each midpoint. Moreover, in this table, the raw score followed by its percentage in the normative sample is presented.

From these age–education-adjusted scaled scores, a new cognitive profile of the a-BT was designed (Table 6). This profile includes all scaled scores (from 2 to 18) and percentile ranks. Furthermore, the classification of ability levels is shown: very impaired, impaired, low average, average, high average, superior, and very superior.

Discussion

The purpose of the present study was to provide new normative data, from a multicenter project, of the a-BT. This brief test includes the main neuropsychological areas and only takes 30–45 min to administer. It is, therefore, a test situated between screening tests and comprehensive neuropsychological batteries, such as the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS; Randolph, 1998) or the ADAS-Cog (Rosen, Mohs, & Davis, 1984).

It is of interest that our results indicate that not all the subtests of the a-BT show the same score distribution. Some of them (e.g., fluency and grammar, informative content of language, orientation, forward and backward series, naming, reading, etc.) have little or null dispersion of data. These kinds of test are, in fact, categorical or qualitative variables. That is to say, a subject repeats well (preservation) in contrast to not repeating well (alteration). A fact had previously been pointed out when the BT was first published (Peña-Casanova, 1990). In other cases (e.g., complex ideational sentence comprehension, pseudoword reading and discrimination, superimposed figures, etc.), the dispersion is partial, which may affect the correct use of the

Table 2. Correlations (r) and shared variances (R^2) of raw scores with age, years of education, and sex (NA: not applicable because shared variance was zero)

Subtest	Age (years)		Education (years)		Sex	
	r	R^2	r	R^2	r	R^2
Fluency and grammar	NA	NA	NA	NA	NA	NA
Informative content of language	−.093	.009	.111*	.012	.050	.002
Personal orientation	−.034	.001	.035	.001	.065	.004
Spatial orientation	−.075	.006	.086	.007	.026	.001
Temporal orientation	−.171**	.029	.063	.004	−.034	.001
Digit Span Forward	−.222***	.049	.475***	.226	−.137*	.019
Digit Span Backward	−.269***	.072	.516***	.266	−.187***	.035
Automatized sequences: Forward series	NA	NA	NA	NA	NA	NA
Automatized sequences: Forward series *T*	−.119*	.014	.204***	.042	−.023	.001
Mental control: Backward series	−.082	.007	.211***	.045	−.033	.001
Mental control: Backward series *T*	−.222***	.049	.415***	.173	−.062	.004
Repetition of pseudowords	−.175***	.031	.203***	.041	.052	.003
Repetition of words	NA	NA	NA	NA	NA	NA
Confrontation naming	−.133*	.018	.081	.006	−.052	.003
Confrontation naming *T*	−.241***	.058	.231***	.054	−.049	.002
Responsive naming	NA	NA	NA	NA	NA	NA
Responsive naming *T*	−.129*	.017	.134*	.018	.021	.000
Semantic fluency (animals)	−.314***	.099	.444***	.197	−.087	.008
Verbal Commands	−.124*	.015	.275***	.076	−.010	.000
Complex ideational sentence compr	−.181***	.033	.351***	.123	−.120*	.014
Complex ideational sentence compr *T*	−.199***	.040	.382***	.146	−.134*	.018
Pseudoword reading	−.062	.004	.227***	.051	−.017	.000
Pseudoword reading *T*	−.086	.007	.273***	.074	−.028	.001
Reading of a text	−.109*	.012	.274***	.075	−.012	.000
Pseudoword reading and discrimination	−.137*	.019	.253***	.064	−.021	.000
Pseudoword reading and discrimination *T*	−.216***	.047	.372***	.139	−.034	.001
Sentences and paragraph reading compr	−.241***	.058	.335***	.112	−.072	.005
Sentences and paragraph reading compr *T*	−.235***	.055	.509***	.259	−.088	.008
Mechanics of writing	NA	NA	NA	NA	NA	NA
Dictated pseudowords	−.030	.001	.088	.008	.113*	.013
Dictated pseudowords *T*	−.321***	.103	.439***	.193	.056	.003
Written picture naming	−.074	.005	.198***	.039	−.053	.003
Written picture naming *T*	−.163**	.027	.270***	.073	−.093	.009
Symbolic gestures (command): right limb	−.106*	.011	.134*	.018	.043	.002
Symbolic gestures (command): left limb	−.170**	.029	.142**	.020	.053	.003
Symbolic gestures (imitation): right limb	−.050	.003	.089	.008	−.024	.001
Symbolic gesture (imitation): left limb	−.095	.009	.115*	.013	−.027	.001
Bimanual pseudogesture imitation	−.262***	.069	.216***	.047	−.012	.000
Alternating sequences: right limb	−.279***	.078	.334***	.112	.057	.003
Alternating sequences: left limb	−.266***	.071	.300***	.090	.037	.001
Constructional praxis (drawing copy)	−.213***	.045	.482***	.232	−.094	.009
Constructional praxis-(drawing copy *T*)	−.321***	.103	.561***	.315	−.090	.008
Superimposed figures	−.310***	.096	.295***	.087	.129*	.017
Superimposed figures *T*	−.366***	.134	.336***	.113	.126*	.016
Story (narrative fragment) free recall	−.384***	.148	.529***	.280	.049	.002
Story cued recall	−.338***	.114	.499***	.249	.030	.001
Delayed story free recall	−.394***	.155	.488***	.238	−.068	.005
Delayed story cued recall	−.348***	.121	.473***	.224	.039	.002
Visual memory	−.480***	.231	.555***	.308	−.010	.000
Arithmetic	−.228***	.052	.627***	.393	−.318***	.101
Arithmetic *T*	−.228***	.052	.616***	.380	−.349***	.122
Similarities	−.325***	.105	.637***	.406	−.052	.003
Digit-symbol (coding)	−.498***	.248	.659***	.435	−.059	.004
Block design	−.346***	.120	.484***	.234	−.064	.004
Block design *T*	−.377***	.142	.507***	.257	−.089	.008

Notes: *T* = time scored; compr = comprehension.
*$p < .05$.
**$p < .01$.
***$p < .001$.

Table 3. Age-adjusted scores (SS_A) for story (narrative fragment) free recall

Scaled score	Percentile range	Age range (years)									
		50–56	57–59	60–62	63–65	66–68	69–71	72–74	75–77	78–80	81+
2	<1	3–4	3–4	3–4	3	3	3	3	3–4	3–5	3–5
3	1	5–6	5	5	4–5	4	4	4	5		
4	2					5	5	5			
5	3–5	7	6	6	6						
6	6–10	8	7	7	7	6–7	6–7	6	6	6	6
7	11–18	9–10	8–9	8–9	8–9	8–9	8–9	7–8	7	7	
8	19–28	11–12	10–11	10–11	10	10	10	9	8		7
9	29–40	13	12–13	12	11	11	11	10	9–10	8–9	8
10	41–59	14	14	13–14	12–13	12–13	12	11–12	11	10	9–10
11	60–71	15–16	15	15	14	14	13–14	13	12	11	
12	72–81		16	16	15–16	15–16	15	14–15	13–14	12–13	11–12
13	82–89	17–18	17	17	17	17	16		15	14–15	13
14	90–94		18	18	18	18	17–18	16–17	16		
15	95–97	19			19	19		18	17	16	14–15
16	98	20	19	19			19	19	18–19	17	
17	99	—	20	20							
18	>99	21	21	21	20–21	20–21	20–21	20–21	20–21	18–21	16–21
Age range		50–60	53–63	56–66	59–69	62–72	65–75	68–78	71–81	74–84	77+ (77–90)
Sample size		132	128	121	104	121	126	127	102	66	43

Table 4. Story (narrative fragment) free recall

SS_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	5	4	4	4	4	3	3	3	3	2	2	2	2	2	1	1	1	1	0	0
3	6	6	5	5	5	5	4	4	4	4	3	3	3	3	3	2	2	2	2	1	1
4	7	7	6	6	6	6	5	5	5	5	4	4	4	4	4	3	3	3	3	2	2
5	8	8	7	7	7	7	6	6	6	6	5	5	5	5	5	4	4	4	4	3	3
6	9	9	8	8	8	8	7	7	7	7	6	6	6	6	6	5	5	5	5	4	4
7	10	10	9	9	9	9	8	8	8	8	7	7	7	7	7	6	6	6	6	5	5
8	11	11	10	10	10	10	9	9	9	9	8	8	8	8	8	7	7	7	7	6	6
9	12	12	11	11	11	11	10	10	10	10	9	9	9	9	9	8	8	8	8	7	7
10	13	13	12	12	12	12	11	11	11	11	10	10	10	10	10	9	9	9	9	8	8
11	14	14	13	13	13	13	12	12	12	12	11	11	11	11	11	10	10	10	10	9	9
12	15	15	14	14	14	14	13	13	13	13	12	12	12	12	12	11	11	11	11	10	10
13	16	16	15	15	15	15	14	14	14	14	13	13	13	13	13	12	12	12	12	11	11
14	17	17	16	16	16	16	15	15	15	15	14	14	14	14	14	13	13	13	13	12	12
15	18	18	17	17	17	17	16	16	16	16	15	15	15	15	15	14	14	14	14	13	13
16	19	19	18	18	18	18	17	17	17	17	16	16	16	16	16	15	15	15	15	14	14
17	20	20	19	19	19	19	18	18	18	18	17	17	17	17	17	16	16	16	16	15	15
18	21	21	20	20	20	20	19	19	19	19	18	18	18	18	18	17	17	17	17	16	16

Notes: Education adjustment applying the following formula: $SS_{AE} = SS_A - (\beta \times [\text{education (years)} - 12])$, where $\beta = 0.2596$. SS_A = age-adjusted scaled scores; SSAE = age–education-adjusted scaled scores.

Table 5. Percent distribution of raw scores in selected subtest and age-adjusted scores (SS_A) for all age range of each midpoint

Subtest	Raw score (%)	Scale score 2, percentile range <1	Scale score 18, percentile range >99
Fluency and grammar	10 (100)	9	10
Automatized sequences: Forward series	1 (0.3)	2	3
	2 (6.9)		
	3 (92.8)		
Repetition of words	10 (100)	9	10
Responsive naming	6 (100)	5	6
Mechanics of writing	5 (100)	4	5

Table 6. Cognitive profile of abbreviated Barcelona Test

Subtest percentiles	<1	1	2	3–5	6–10	11–18	19–28	29–40	41–59	60–71	72–81	82–89	90–94	95–97	98	99	>99
Classification of ability levels	Very impaired				I	LA	Average					HA	Superior		Very superior		
Fluency and grammar	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Informative content of language	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Personal orientation	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Spatial orientation	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Temporal orientation	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Digit Span Forward	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Digit Span Backward	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Automatized sequences: Forward series	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Automatized sequences: Foward series *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mental control: Backward series	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mental control: Backward series *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Repetition of pseudowords	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Repetition of words	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Confrontation naming	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Confrontation naming *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Responsive naming	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Responsive naming *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Semantic fluency (animals)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Verbal commands	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Complex ideational sentence compr	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Complex ideational sentence compr *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pseudowords reading	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pseudowords reading *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Reading of a text	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pseudoword reading and discrimination	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pseudoword reading and discrimination *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sentences & paragraph reading compr	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Sentences & paragraph reading compr *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Mechanics of writing	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Dictated pseudowords	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Dictated pseudowords *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Writing picture naming	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Writing picture naming *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Symbolic gesture (command, right)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Symbolic gesture (command, left)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Symbolic gesture (imitation, right)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Symbolic gesture (imitation, left)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Bimanual pseudogesture imitation	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alternating sequences: right limb	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Alternating sequences: left limb	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Constructional praxis-copy	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Constructional praxis-copy *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Superimposed figures	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Superimposed figures *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Story (narrative fragment) free recall	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Story cued recall	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Delayed story: free recall	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Delayed story: cued recall	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Visual memory	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Arithmetic	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Arithmetic *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Similarities	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Digit-symbol (coding)	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Block design	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Block design *T*	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

Notes: I = impaired; LA = low average; HA = high average; *T* = time score; compr = comprehension.

overall Neuronorma analysis method based on normal distributions. This problem also appears in other neuropsychological tasks such as digit repetition (Peña-Casanova, Quiñones-Úbeda, Quintana-Aparicio, et al., 2009) or in some subtests of the Visual Object and Space Perception Battery (Peña-Casanova, Quintana-Aparicio, Quiñones-Úbeda, et al., 2009). To minimize this effect, some authors suggest dealing with data in a raw score form rather than converting them into scaled scores (Lezak et al., 2004). We certainly agree with such a proposition and recognize the statistical problems of forcing these kinds of scores into a normal distribution. Finally, the rest of the subtests (e.g., semantic fluency, constructional praxis-drawing copy, all measures of memory, digit-symbol, arithmetic, similarities, and block design) show a clear variability of scores.

In spite of the psychometrically different measures, given the characteristics and purposes of this normative project, we decided to maintain the same model of statistical analysis for all the subtests. Thus, we developed normative data following the single procedure used in the Neuronorma project.

The normative data used should be recent because when a test is re-normed, there is typically a reduction in the resulting standard scores with the new version (Pae et al., 2005). As a result, a better performance with regard to the original sample, and a consequent over-estimation of performance, will be found with regard to the original norms (Baxendale, 2010; Iverson, Franzen, & Lovell, 1999; Hiscock, 2007). Starting from this premise, the "Flynn effect" (Flynn, 1984, 1987) could be connected. Related IQ effect notwithstanding, it is important to adopt new norms in neuropsychology (Bush, 2010; Strauss et al., 2006).

Consistent with the findings of previous studies (Cejudo-Bolívar et al., 1998; García-Morales et al., 1998; Gramunt-Fombuena et al., 1998; Peña-Casanova et al., 2005; Peña-Casanova, Meza, et al., 1997), age and education contributed to the raw score on most subtests of the a-BT. Consequently, adjustments were necessary so raw scores were converted to SS_A. This transformation generated a normal distribution for a posterior application of a regression model to adjust for education. Thanks to this, the method applied to all subtests and we developed a single record form for the representation of test results (Table 6). In this cognitive profile, the percentile ranks for each scaled score are presented. The combination between scaled scores and percentiles ranks has been considered the best possible way to express normative data (Crawford & Garthwaite, 2009).

Furthermore, the cognitive profile is very useful as a visual representation of the test performance to facilitate interpretation (Bowman, 2002; Strauss et al., 2006). It is well suited to documenting the specific cognitive changes or constancies that can occur with disease progression. On the other hand, it permits comparison with other test results due to the fact that the norms of the a-BT were obtained from the same study sample and the same statistical procedures for data analyses as all the other Neuronorma normative data (Peña-Casanova, Blesa, et al., 2009). This procedure has been used to enhance the comparison with cognitive scores, both at a single point in time and across time, and it is able to simultaneously obtain multiple data for the same normative sample (Smith & Ivnik, 2003). It also permits the establishment of a cognitive profile separate from cognitive domains and the comparison among other neuropsychological tests (Kern et al., 2008). These co-normed data will allow clinicians to compare scores from the a-BT with all the tests included in the Neuronorma project. However, the validity of these norms is heavily dependent upon the similarity between the characteristics of the patient being assessed and the demographic, cultural, and linguistic features of the normative sample (Ivnik et al., 1992a). Therefore, the Neuronorma normative data may not apply to all Spanish-speaking populations.

There has recently been an increase in co-norming tests and batteries (Attix et al., 2009) including the outstanding Mayo Clinic Studies known as Mayo's Older Americans Studies (Ivnik et al., 1992a, 1992b, 1992c; Machulda et al., 2007; Steinberg, Bieliauskas, Smith, & Ivnik, 2005a, 2005b) and Mayo's Older African Americans Normative Studies (MOAANS) (Ferman et al., 2005; Lucas, Ivnik, Willis, et al., 2005; Lucas et al., 2005a, 2005b, 2005c; Pedraza et al., 2005; Rilling et al., 2005), and in a Spanish population, the Neuronorma Project (Peña-Casanova, Blesa, et al., 2009; Peña-Casanova, Gramunt-Fombuena, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Aguilar, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Quintana, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Gramunt-Fombuena, Quintana-Aparicio, et al., 2009; Peña-Casanova, Quiñones-Úbeda, Quintana-Aparicio, et al., 2009; Peña-Casanova, Quintana-Aparicio, Quiñones-Úbeda, et al., 2009).

There are several limitations of the present study. First, the large number of normative tables generated. This fact is, however, inherent to the statistical procedures applied (overlapping cell procedure, midpoint, age, and education adjustments). One possible solution could be a computer application to convert the raw scores to the appropriate age and education adjustment scale scores. Secondly, we presented norms for age ranging from 50 to 90 years; therefore, no new normative data under 50 years are available for this set of norms using the Neuronorma method. These and other general limitations of Neuronorma project have been discussed in a previous paper (Peña-Casanova, Blesa, et al., 2009).

Despite its limitations, the methods used to obtain the norms for the a-BT (e.g., the conversion to age and education scaled scores, overlapping cell procedure, and midpoint) show a series of advantages. For example, this method signifies that the group means are more stable, resulting in less abrupt mean shifts between age blocks (Busch, Chelune, & Suchy, 2006).

Moreover, it manages to solve the limitation of using large groups that are age-stratified with no overlapping by allowing the comparison with more adjacent ages.

We also obtained the same metric for all the subtests which made one cognitive profile possible. In the original normative data (Peña-Casanova, Guardia, et al., 1997), five different cognitive profiles were published. Moreover, the sample came from different Spanish regions (for more information, *see* Peña-Casanova, Blesa, et al., 2009); therefore, it was a multicenter project and thus achieved a better representation of the Spanish population. Finally, the normative data for the a-BT were developed in conjunction with norms for all the neuropsychological tests comprising the Neuronorma test battery. This same co-norming process had been previously used by Rilling and colleagues (2005) for older African Americans on the Mattis Dementia Rating Scale, as part of the MOAANS project.

We anticipate that this feature of Neuronorma norms will facilitate interpretation of a-BT performance within the context of a patient's overall neuropsychological profile, although the a-BT is of interest on its own as a general cognitive functioning battery. Moreover, it can be used as a complement to the Neuronorma battery, since it includes cognitive domains not assessed by the battery such as orientation, reading, writing, repetition, graphic constructional praxis for simple figures, symbolic gesture, numerical reasoning, and concept formation.

In summary, the a-BT is a brief test and the normative data presented in this study could be very useful for neuropsychologists interested in assessing the cognitive functioning of the Spanish population.

Supplementary material

Supplementary material is available at *Archives of Clinical Neuropsychology* online.

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Conflict of Interest

None declared.

Appendix A

Variables of the abbreviated Barcelona Test

#	Subtest	Description	NI	Scoring	Score range
1	Fluency and grammar	Conversation, picture description, and narrative speech tasks	—	Categorical descriptive rating scale from nonfluent to fluent speech	0–10
2	Informative content of language	Conversation, picture description, and narrative speech tasks	—	Informative content rating scale from no information to normality	0–10
3	Personal orientation	Questions on: First name and last name, age, date of birth, place of birth, relative's names, address, and occupation	7	Correct: 1 point Incorrect: 0 point	0–7
4	Spatial orientation	Questions on: City, neighborhood, type of place, name of the place, and floor	5	Correct: 1 point Incorrect: 0 point	0–5

(*continued on next page*)

(*continued*)

#	Subtest	Description	NI	Scoring	Score range
5	Temporal orientation	Questions on: Date, day of the week, time, month, part of the day, and year	6	Correct: 1 point Incorrect: 0 point For month correct: 5 points For year correct: 10 points For part of the day correct: 5 points	0–23
6	Digit Span Forward	Repetition of digit sequences of increasing length (3–9) forward	7	The most large string repeated forward	0–9
7	Digit Span Backward	Repetition of digit sequences of increasing length (2–8) backward	7	The most large string repeated backward	0–8
8	Automatized sequences: Forward series	Counting to 20, days of the week, and months of the year	3	Correct: 1 point Incorrect: 0 point	0–3
9	Automatized sequences: Forward series time	Time scored in forward automatized series		0-1-2 depending on time	0–6
10	Mental control: Backward series	Reversal of the series included in subtest # 8	3	Correct: 1 point Incorrect: 0 point	0–3
11	Mental control: Backward series time	Time scored in backward automatized series		0-1-2 depending on time	0–6
12	Repetition of pseudowords	For example, sinapo, sotupo, basomida, adicapo	8	Correct: 1 point Incorrect: 0 point	0–8
13	Repetition of words	For example, silla, botella, cuchara, elefante [chair, bottle, spoon, elephant]	10	Correct: 1 point Incorrect: 0 point	0–10
14	Confrontation naming	14 line drawings of different entities (e.g., cow, spoon, bottle, ship)	14	Correct: 1 point Incorrect: 0 point	0–14
15	Confrontation naming time	Time scored in confrontation naming		0-1-2-3 depending on time	0–42
16	Responsive naming	Answer a question through a word (e.g., What do you do with a pencil?)	6	Correct: 1 point Incorrect: 0 point	0–6
17	Responsive naming time	Time scored in responsive naming		0-1-2-3 depending on time	0–18
18	Semantic fluency (animals)	Generation of as many names of animals as possible in 1 min		1 point for each acceptable response	Unlimited
19	Verbal Commands	To carry out commands of increasing difficulty (e.g., make a fist, put the pencil on top of the card, then put it back)	6	1 point for each correct command	0–16
20	Complex ideational sentence comprehension	Answer yes/no a question (e.g., is a dog bigger than a horse? and are a father's brother and a brother's father the same?)	9	Correct: 1 point Incorrect: 0 point	0–9
21	Complex ideational sentence comprehension time	Time scored in complex ideational comprehension		0-1-2-3 depending on time	0–27
22	Pseudoword reading	E.g., lafu, tumo, tolamo, and so forth	6	Correct: 1 point Incorrect: 0 point	0–6
23	Pseudoword reading time	Time scored in reading pseudowords		0-1-2-3 depending on time	0–18
24	Reading of a text	Reading a 56-word text	56	1 point for each word correctly read	0–56
25	Pseudoword reading and discrimination	Pointing pseudowords through multiple choice	6	Correct: 1 point Incorrect: 0 point	0–6
26	Pseudoword reading and discrimination time	Time scored in pseudoword reading and discrimination		0-1-2-3 depending on time	0–18
27	Sentence and paragraph reading comprehension	Multiple-choice sentence/paragraph completion (four alternatives)	8	Correct: 1 point Incorrect: 0 point	0–8
28	Sentence and paragraph reading comprehension time	Time scored in sentence and paragraph reading comprehension		0-1-2-3 depending on time	0–24
29	Mechanics of writing	Coping a sentence and spontaneous writing	1	0–5 qualitative scale (state of the grapho-motor skills)	0–5
30	Dictated pseudowords	Dictated pseudowords (e.g., lafo, togamo, tumi)	6	Correct: 1 point Incorrect: 0 point	0–6
31	Dictated pseudowords time	Time scored in dictated pseudowords		0-1-2-3 depending on time	0–18
32	Written picture naming	To write the name of the item shown (e.g., spoon, air-plane, pencil, cow)	6	Correct: 1 point Incorrect: 0 point	0–6
33	Written picture naming time	Time scored in written picture naming		0-1-2-3 depending on time	0–18

(*continued on next page*)

(*continued*)

#	Subtest	Description	NI	Scoring	Score range
34	Symbolic conventional gestures (commands): right limb/hand	To carry out symbolic gestures for communication (commands, right limb/hand; e.g., How would you pretend to. . .wave good bye, salute like a soldier, etc.)	5	Correct: 2 points Impaired: 1 point Failed: 0 point	0–10
35	Symbolic conventional gestures (commands): left limb/hand	Items of subtest #34: commands, left limb/hand	5	Correct: 2 points Impaired: 1 point Failed: 0 point	0–10
36	Symbolic conventional gestures (imitation): right limb/hand	Items of subtest #34: imitation, right limb/hand	5	Correct: 2 points Impaired: 1 point Failed: 0 point	0–10
37	Symbolic conventional gestures (imitation): left limb/hand	Items of subtest #34: imitation, left limb/hand	5	Correct: 2 points Impaired: 1 point Failed: 0 point	0–10
38	Bimanual pseudogesture imitation	Pseudogesture imitation with two hands (e.g., forming a *ring* with each hand and then putting one *ring* in the hole)	4	Correct: 2 points Impaired: 1 point Failed: 0 point	0–8
39	Alternating sequences: right limb/hand	Serial hand sequences (e.g., fist-palm-side, tapping, graphic—pencil—test of alternation)	4	Correct: 2 points Impaired: 1 point Failed: 0 point	0–8
40	Alternating sequences: left limb/hand	Items of subtest #39: left limb/hand	4	Correct: 2 points Impaired: 1 point Failed: 0 point	0–8
41	Constructional praxis (drawing copy)	To copy of six figures: circle, square, triangle, cross, cube, and house	6	Correct: 3 points Minor changes: 2 points Impaired: 1 point Failed: 0 point	0–18
42	Constructional praxis (drawing copy) time	Time scored in drawing copy		Bonus: 1-2-3 depending on time	0–36
43	Superimposed figures	To identify line drawings of various objects superimposed upon one another (five cards on which were drawn four superimposed line drawings)	5	1 point for each object correctly recognized	0–20
44	Superimposed figures time	Time scored in the overlapping figures test		Bonus: 1-2-3 depending on time	0–35
45	Story (narrative fragment) free recall	The examinee listens two each of two narrative fragments (with 9 and 14 items, respectively) and immediately after hearing each is asked to retell it from memory	23	Item correctly repeated: 1 point Partially correct item: 0.5 point	0–23
46	Story cued recall	A standard question cue is provided when an item is not spontaneously remembered	23	Item correctly repeated after cue: 1 point Partially correct item after cue: 0.5 point	0–23
47	Delayed story free recall	Five minutes after the completion of immediate recall examinee is asked to remember the two narratives	23	Item correctly repeated: 1 point Partially correct item: 0.5 point	0–23
48	Delayed story cued recall	A standard question cue is provided when an item is not spontaneously remembered	23	Item correctly repeated after cue: 1 point Partially correct item after cue: 0.5 point	0–23
49	Visual memory	Reproduction of five simple line drawings of increasing difficulty after a 10 s presentation of the design and 10 s delay (with interference). Designs 4 and 5 are presented together	5	Each design is scored on a four-point scale (0–3) except designs 4 and 5 that are scored on a five-point score (0–4)	0–16
50	Arithmetic	Ten mental arithmetic problems	10	Correct: 1 point Incorrect: 0 point	0–10
51	Arithmetic time	Time scored in arithmetic problem resolution		0-1-2 depending on time	0–20
52	Similarities	To say in what way two objects or concepts are alike (e.g., In what way are a dog and a lion alike?)	6	Correct: 2 points (abstract similarity) Poor: 1 point Failed: 0 point Incorrect: 0 point	0–12
53	Digit-symbol (coding)	Copying a coding pattern in 60 s	60	Correct: 1 point Incorrect: 0 point	0–60
54	Block design	To arrange blocks according to a model (six models)	6	Correct: 1 point Incorrect: 0 point	0–6
55	Block design time	Time scored in block design		0-1-2-3 depending on time	0–18

Note: NI = number of items.

Appendix B

Steering committee: J.P.-C., Hospital del Mar, Barcelona, Spain; R.B., Hospital de la Santa Creu i Sant Pau, Barcelona, Spain; M.A., Hospital Mútua de Terrassa, Terrassa, Spain.

Principal investigators: J.P.-C., Hospital de Mar, Barcelona, Spain; R.B., Hospital de la Santa Creu i Sant Pau, Barcelona, Spain; M.A., Hospital Mútua de Terrassa, Terrassa, Spain; J.L.M., Hospital Clínic, Barcelona, Spain; A.R., Hospital Clínico Universitario, Santiago de Compostela, Spain; M.S.B., Hospital Clínico San Carlos, Madrid, Spain; C.A., Hospital Virgen Arrixaca, Murcia, Spain; C.M.-P., Hospital Virgen Macarena, Sevilla, Spain; A.F.-G., Hospital Universitario La Paz, Madrid, Spain; M.F., Hospital de Cruces, Bilbao, Spain.

Genetics substudy: Rafael Oliva, Service of Genetics, Hospital Clínic, Barcelona, Spain.

Neuroimaging substudy: Beatriz Gómez-Ansón, Radiology Department and IDIBAPS, Hospital Clínic, Barcelona, Spain.

Research Fellows: Gemma Monte, Elena Alayrach, Aitor Sainz, and Claudia Caprile, Fundació Clinic, Hospital Clinic, Barcelona, Spain; Gonzalo Sánchez, Behavioral Neurology Group. Institut Municipal d'Investigació Médica. Barcelona, Spain.

Clinicians, Psychologists and Neuropsychologists: Nina Gramunt (Coordinator), Peter Böhm, Sonia González, Yolanda Buriel, María Quintana, Sonia Quiñones, Gonzalo Sánchez, Rosa M. Manero, Gracia Cucurella, Institut Municipal d'Investigació Mèdica. Barcelona, Spain; Eva Ruiz, Mónica Serradell, Laura Torner, Hospital Clínic. Barcelona, Spain; Dolors Badenes, Laura Casas, Noemí Cerulla, Silvia Ramos, Loli Cabello, Hospital Mútua de Terrassa, Terrassa, Spain; Dolores Rodríguez, Clinical Psychology and Psychobiology Dept. University of Santiago de Compostela, Spain; María Payno, Clara Villanueva, Hospital Clínico San Carlos. Madrid, Spain; Rafael Carles, Judit Jiménez, Martirio Antequera, Hospital Virgen Arixaca. Murcia, Spain; Jose Manuel Gata, Pablo Duque, Laura Jiménez, Hospital Virgen Macarena. Sevilla, Spain; Azucena Sanz, María Dolores Aguilar, Hospital Universitario La Paz. Madrid, Spain; Ana Molano, Maitena Lasa, Hospital de Cruces. Bilbao, Spain.

Data management and biometrics: Josep Maria Sol, Francisco Hernández, Irune Quevedo, Anna Salvà, Verónica Alfonso, European Biometrics Institute. Barcelona, Spain.

Administrative management: Carme Pla,† Romina Ribas, Department of Psychiatry and Forensic Medicine, Universitat Autònoma de Barcelona, and Behavioral Neurology Group. Institut Municipal d'Investigació Mèdica. Barcelona, Spain.

English edition: Stephanie Lonsdale, Program of Neuropsychopharmacology, Institut Municipal d'Investigació Mèdica, Barcelona, Spain.

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