Population Norms of the tablet-administered Brief Assessment of Cognition

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The Methodological Issue Being Addressed

Digital cognitive assessments improve efficiency and standardization in evaluating cognitive impairment, a key feature of many CNS disorders. This study addresses this need by establishing normative benchmarks for the tablet-based Brief Assessment of Cognition (BAC)[1,2]. Normative data are useful to compare the performance of clinical groups or individuals to the general population and to adjust for the impact of demographic factors (age, sex, etc.).

Introduction

Cognitive impairment impacts daily functioning and quality of life across CNS disorders. The BAC offers a brief, standardized, semi-automated assessment of core cognitive domains via a tablet. This study aims to generate normative data for the BAC using a large, demographically representative sample of healthy adults.

Domain	Test Name	Description	Duration (mins)
Verbal Memory & Learning	Verbal Memory (Learning) (VM)	Subject is presented with 15 unrelated words and asked to recall as many as possible. This procedure is repeated 5 times. There are seven alternate forms. Outcome measure: Total number of words recalled (Trials 1-5)	7
Working Memory	Digit Sequencing (DS)	Subject is presented with auditory clusters of numbers (e.g. 9, 3, 6) of increasing length and asked to recount the numbers in order from lowest to highest. Outcome measure: Number of correct responses	5
Motor Function	Token Motor (TM)	Subject is presented with tokens and asked to drag them to a center container as quickly as possible for 60 seconds. Outcome measure: Number of tokens correctly dragged into the container	3
Verbal Fluency	Semantic Fluency Letter Fluency (VF)	Subject is given 60 seconds to name as many animals as possible. In two separate trials, subject is given 60 seconds to verbally generate as many words as possible beginning with a given letter of the alphabet (F, S). Outcome measure: Total numbers of words generated across both fluency tasks.	5
Speed of Processing	Symbol Coding (SC)	Subject is provided a key and asked to fill in the corresponding numbers beneath a series of symbols as quickly as possible within 90 seconds. Outcome measure: Number of correct items	3
Executive Function	Tower of London (TL)	Subject is asked to give the minimum number of times the balls in one picture would need to be moved in order to make the arrangement of balls identical to that in the opposing picture. Outcome measure: Number of correct responses	7

Table 1: Cognitive tests included in the BAC platform

Methods

A normative sample of 626 healthy adults (≥20 years) was recruited via local advertisements and stratified by age and sex to match U.S. Census demographics. Subjects qualified for the Healthy Normative Group if they were cognitively normal, as determined by a MoCA score ≥22 and if they did not present significant self-reported memory complaints as defined by a Cognitive Function Instrument (CFI) score ≥4. Other exclusion criteria included non-English speakers, major psychiatric/neurological conditions, recent head injury, substance abuse, daily drug use, and cognition-impairing medications.

For each of six BAC subtests, multiple linear regressions were conducted using two covariate sets: (1) age and sex, and (2) age, sex, and education. Model diagnostics confirmed adequate linearity and normality. The detected heteroscedasticity was addressed using two methods: Box-Cox transformations and a linear model with explicit variance modeling. Following appropriate modeling, significance tests were performed on all covariates. Finally, predicted means and standard deviations were computed across all combinations of age (18–90), sex (Male/Female), and education (High/Low) to derive z- and t-scores for all subtests and the composite.

Characteristic	20-29	30-39	40-49	50-59	60-69	70-79	80+	Total Sample
n	60	57	91	103	139	123	53	626
Sex (% Female)	51.7%	43.9%	57.1%	56.3%	52.5%	56.9%	56.6%	54.2%
Education (Years, SD)	14.5 (2.2)	13.4 (2.1)	14.3 (2.3)	14.6 (2.4)	14.7 (2.7)	14.8 (2.5)	15.3 (2.9)	14.6 (2.5)
Education (>15 Years %)	28.3%	17.5%	35.2%	33.0%	33.8%	34.1%	41.5%	32.6%
Race (% Caucasian)	68.3%	66.7%	65.9%	68.0%	75.5%	81.3%	94.3%	74.1%

Table 2: Participant Demographic Characteristics by Age Group

BAC Subtest	20-29	30-39	40-49	50-59	60-69	70-79	80+	Total Sample
VM	47.0 (9.3)	46.3 (7.9)	44.1 (8.8)	42.7 (7.9)	40.9 (8.9)	38.7 (8.2)	34.7 (8.8)	41.8 (9.2)
DS	20.6 (4.1)	20.6 (3.9)	20.1 (4.2)	20.5 (4.0)	20.2 (3.9)	19.5 (3.8)	19.5 (3.4)	20.1 (4.0)
TM	107.0 (30.5)	96.5 (29.5)	81.5 (23.5)	73.8 (26.7)	63.7 (24.0)	52.3 (18.0)	44.3 (13.9)	71.3 (30.2)
VF	56.0 (12.6)	55.3 (13.4)	56.6 (14.2)	54.2 (12.3)	53.0 (12.8)	50.1 (12.1)	45.9 (11.4)	53.1 (13.0)
SC	57.9 (10.7)	52.6 (11.5)	47.6 (10.3)	41.1 (8.2)	36.4 (9.9)	30.6 (8.9)	25.5 (7.6)	40.3 (13.5)
TL	17.3 (1.9)	17.3 (2.8)	16.3 (3.6)	16.5 (2.7)	16.1 (3.3)	15.6 (2.9)	15.3 (2.2)	16.3 (3.0)

Table 3: Stratified Performance on BAC Subtests by Age Group

Results

Age negatively predicted performance on most subtests—Verbal Memory, Token Motor, Verbal Fluency, Symbol Coding, and Tower of London ($p < 0.01$)—with a borderline effect for Digit Sequencing ($p = 0.06$). Sex was generally nonsignificant, except females outperformed males on Verbal Memory ($p < 0.01$). Education showed a positive effect across all subtests ($p < 0.01$), except Token Motor ($p = 0.07$).

Figure 1: Age-Related Performance in BAC Subtests by Education Level

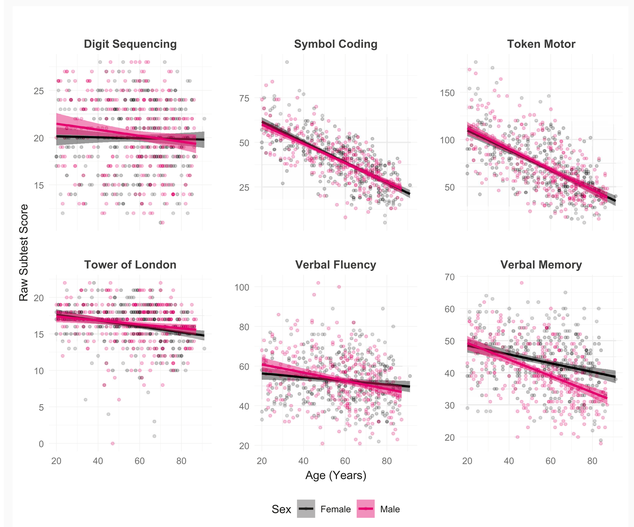

Figure 2: Age-Related Performance in BAC Subtests by Sex

Table 4. Statistical Significance of Age and Sex Predictors Across BAC Subtests

Model (AGE + SEX)			
Cognitive Subtest	Age (p-value)	Sex (p-value)	Adjusted R^2
VM	<.001	<.001	0.16
DS	ns	ns	0.01
TM	<.001	ns	0.38
VF	<.001	ns	0.04
SC	<.001	ns	0.51
TL	<.001	ns	0.04

Conclusions

This study provides normative BAC data derived from a demographically representative sample of 626 healthy adults, enabling calculation of age-, sex-, and/or education- adjusted standardized scores (z- and t-scores) for individual subtests and the composite score. In some indications, education may be excluded as a covariate because illness-related cognitive deficits can truncate educational attainment, and adjusting for it risks removing relevant variance. Although the sample was geographically concentrated in Durham, North Carolina, its educational distribution closely approximates national patterns, supporting the generalizability of these norms.

Disclosures

DS, MW and CAB are full-time employees of Clario. Clario owns and distributes the paper BACS and the tablet administered BAC.
ASA contributed to the present work as a former full-time employee at VeraSci. She is currently a full-time employee and minor shareholder in Eli Lilly.
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