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FEATURED ARTICLE

COGNITO (Computerized assessment of adult information processing): Normative scores for a rural Indian population from the SANSCOG study

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Abstract

Introduction: Neuropsychological assessments are inexpensive and efficient methods to understand the cognitive abilities of individuals in research studies and clinical settings. Normative scores for such measures are crucial in serving as a reference standard for identifying cognitively healthy and impaired individuals belonging to similar sociodemographic characteristics.

Methods: Study subjects in rural India recruited into the Srinivaspura Aging, Neuro Senescence and Cognition (SANSCOG) study were administered the COGNITO battery of tests, which traverse cognitive domains of attention, memory, language, and visuospatial abilities. Percentile norms based on age and education stratification were derived for the above cohort.

Results: Percentile norms are commensurate with literacy levels in this population. The percentile scores for the cognitive tests show a decline for the individuals aged 75 years and above indicating lower cognitive functioning in this age group.

Discussion: This is the first-ever study reporting norms for diverse cognitive domains for illiterate, literate, low-literate individuals enrolled in a large-scale community-based cohort study in rural India.

KEYWORDS
age, COGNITO, literacy levels, neuropsychological assessments, normative scores, rural India

1 | INTRODUCTION

The older population across the world is growing rapidly. It is estimated that by 2050, the number of elderly persons (aged 65 years or above) will reach 1.5 billion.[1] Consequentially, the burden of aging-related disorders will also escalate significantly. For example, the number of persons with dementia around the world is expected to cross 100 million by 2050.[2] With no curative or disease-modifying treatments available for dementia, primary and secondary prevention strategies are vital to tackle this enormous public health problem and recent research has been directed toward this. However, research evidence on dementia from low- and middle-income countries (LMICs), including India, is minimal, although the majority of new dementia cases in the coming decades will be from LMICs.[3,4]

It is now well known that the underlying pathological process of dementia begins decades before presentation of the overt clinical symptoms.[5] It is also becoming evident that subtle cognitive changes can appear and progress long before the appearance of diagnosable

clinical manifestations.[6] Hence, there is a growing effort to detect the onset and progression of cognitive changes to help early diagnosis of the disease.[7] Comprehensive neuropsychological test batteries are an important measure to detect such early cognitive changes. Neuropsychological batteries assess a wide range of cognitive skills for various cognitive domains, such as memory, attention, language, processing speed, reasoning, and visuo-spatial abilities. A reference scoring of neuropsychological assessments for healthy individuals in a population facilitates correct interpretation of cognitive status of individuals tested based on their sociodemographic conditions, thereby allowing identification of cognitively healthy and demented individuals. Additionally, serial administration of such detailed neuropsychological assessment in longitudinal studies in healthy aging individuals can help determine the differential trajectories of normal versus pathological cognitive aging leading to dementia and related disorders.

The Srinivaspura Aging, Neuro Senescence and Cognition (SANSCOG) is an ongoing, large-scale longitudinal cohort study aimed at identifying the risk and protective factors associated with cognitive changes during normal aging, dementia, and other related disorders. This rural Indian study is being conducted in the villages of Srinivaspura, in the Kolar district in the southern Indian state of Karnataka, and is the twin of the urban Indian study (Tata Longitudinal Study of Aging [TLSA]) that is being conducted in Bangalore city in the same state. The study uses an interdisciplinary approach in which detailed clinical, neurocognitive, biochemical, genetic, and neuroimaging assessments are carried out on individuals aged 45 and above, with long-term follow-up. Further details of the study are available in the SANSCOG study protocol paper.[8]

One of the key strengths of this rural (SANSCOG) study is systematic and extensive cognitive testing, which is digitized as well as fully adapted to the local languages (Indian English, Kannada, and Telugu) and socio-cultural context.[9] Computerized neuropsychological testing is known to provide high accuracy and standardized stimulus presentation. Because there is significant reduction in the administration time for these tests, it makes comprehensive testing possible within large cohort studies.[10] The computerized cognitive assessment battery, namely, the COGNITO (Computerized assessment of adult information processing) covers four principal areas of cognitive functioning—attention, memory, visuospatial processing, and language—and has been shown to detect mild cognitive changes in pre-clinical stages of dementia. The component tests cover both quantitative and qualitative aspect of cognitive performance and can be used for clinical as well as epidemiological research.[10] The majority of the tests in this battery record responses through a touchscreen, enabling its use in literate, lesser-educated, and illiterate individuals. It offers tests with a wider range of difficulty levels, to avoid ceiling and floor effects.[10]

Cognitive test performance is established to be influenced by education and culture.[11] Various cognitive tests require language and semantic treatment of information, which is influenced by psycholinguistic factors (e.g., word frequency or familiarity) that vary between cultures and languages.[12] Literacy and low levels of education have been shown to be associated with an increased risk for developing dementia.[13] Illiterate and low-literacy adults tend to perform poorly on many of the conventional cognitive assessment tools, even without evidence of functional or cognitive decline during the clinical history. Most of the neurocognitive assessment tools frequently used have been developed and validated in populations with higher levels of literacy.[14] Some of these differences in performance can be attributed to lack of familiarity with testing material or restriction of assessment to those aspects of cognitive screening traditionally taught in schools such as reading and writing; however, studies also show that it can also influence performance on visuo-spatial and language assessments.[15,16] It is estimated that there are approximately 758 million illiterate adults across the globe. While prospective cohort studies have shown the relationship between low literacy levels and higher chances of developing dementia[17,18,19] very few have examined cognitive assessment tools in adults with low literacy levels.[20] Hence, it is important to develop culturally and linguistically adapted norms to the reference population to accurately detect cognitive impairments.[12]

To date, normative data and psychometric properties of the English version of COGNITO were documented in a population of 78 individuals from France and England with university level education.[10] To the best of our knowledge, there are no studies that have attempted to use this battery to assess cognitive functioning among groups of individuals with varied literacy levels, especially among individuals with lower literacy levels. In the present study we aim to establish age- and literacy-stratified normative data for the tests in COGNITO for a predominantly cognitively normal and lesser literate sample of individuals participating in this rural India-based SANSCOG longitudinal study.

RESEARCH-IN-CONTEXT

1. **Systematic review**: The COGNITO neuropsychological battery assesses individuals in attention, memory, language, and visuospatial cognitive domains. Normative scores for locally and culturally adapted COGNITO have not been reported for the Indian population.
2. **Interpretation**: In this article we present the age- and education level–stratified normative scores for COGNITO in a rural Indian population for healthy individuals aged 45 years and above enrolled in the Srinivaspura Aging, Neuro Senescence and Cognition study.
3. **Future directions**: Our results will aid in assessing the level of cognitive functioning in individuals based on their age and education levels. Because low literacy and illiteracy can be confounding factors and lead to cognitively normal older adults being misclassified as cognitively impaired because of low literacy, our results are a vital development in literacy-specific normative data for sensitive tests adapted to rural India. Addition of more individuals in an even more advanced age group (> 80 years) will further augment the normative scores and facilitate accurate screening of cognitively healthy and impaired individuals.

2 | METHODS

2.1 | Sample

This analytical sample consists of a subset of apparently healthy participants (n = 1440, age ≧ 45 years, males and females) from the SANSCOG study, who had completed their baseline assessments, including the COGNITO neurocognitive battery. These participants were recruited into the SANSCOG study, following an area sampling strategy, with mapping of the catchment areas under the coverage of the respective primary health management units in Srinivaspura. Individuals already diagnosed to have mild cognitive impairment or dementia were excluded from the study.

The study is approved by the institutional human ethics committees at the Centre for Brain Research (CBR) and the collaborating institutes—National Institute of Mental Health and Neurosciences (NIMHANS) in Bangalore. All participants signed the written informed consent form.

2.2 | Tools used

A literacy questionnaire[21] was used to examine the literacy status of participants. This questionnaire assesses an individual's ability to read and write in various daily activities. The tool consists of 11 questions such as "Could you read the tag of an item in a market?," "Can you use street signs to find your way?" and "Can you note the name of the caller on the phone?" Based on the responses, the subjects are classified into different literacy statuses, namely "literates" (those who can read and write fluently), "illiterates" (those who cannot read and write at all), "semi-literates" (those who cannot read *or* write enough to manage daily tasks) and "functional literates" (those who cannot read *and* write enough to manage daily tasks). In the present study, as the number of individuals in the semi- and functional literate category were small, and with the overlap in their abilities to perform on the tasks included in the battery, the individuals in the semi- and functional literate categories were grouped into a single category.

COGNITO (a computerized assessment of adult information processing) was administered to each participant as part of the neuropsychological assessment. This battery, developed by the National Institute of Health and Medical Research (Inserm)—University of Montpellier, France, is a computerized, comprehensive neuropsychological assessment battery. Permission was obtained to cross-culturally adapt this battery and use it for the SANSCOG study. The battery assesses four principal neurocognitive domains of attention, language, memory, and visuo-spatial processing.[10]

Attention is measured through the auditory and visual modalities using an auditory discrimination task, a visual attention task wherein the participants are required to identify a visual stimulus presented among multiple distractor items, and a dual attention task in which the two tasks are performed together. Language is assessed through tasks ranging from a reading and comprehension task, phoneme comprehension test, naming and associations test, fluency, and a vocabulary task, which have been designed to assess phonology, morphology, syntax, and semantics.

Memory is assessed through an immediate and delayed recall of a name list, name–face recall task, visuo-spatial span, and an implicit memory task.

Visuo-spatial processing is assessed based on a construction task, a matrix reasoning task, and a semantic and functional matching task.[10]

The original COGNITO battery has 24 total tests, which fall under one of the four principal cognitive domains (attention, language, memory, and visuospatial processing). For the present study, tests were administered to participants based on their literacy categories and their ability to read and write. Tests that involved reading and writing tasks such as Stroop, vocabulary, implicit memory, and visuospatial construction (which require the use of a pencil), were not administered to illiterates. The narrative recall and descriptive recall, which is a part of the original COGNITO battery, was not administered to any of the participants as it could not be cross-culturally adapted to suit the rural SANSCOG cohort. Tests were administered in two Indian languages—Kannada and Telugu—depending on the language preference of the participant.

2.3 | Data analysis

The socio-demographic details of the participants were analyzed using descriptive statistics (mean, standard deviation). Participants were stratified by age (45–54, 55–64, 65—74, and 75 years and above) and literacy category: specifically literates, illiterates, and semi- and functional literates.

The COGNITO battery automatically produces 1005 variables, both quantitative and qualitative in nature. For ease of normative data calculation, we have selected or computed a single score that can be used as an outcome measure for each test, consisting of scores such as "total correct responses," "total incorrect responses," and computation of scores to obtain a single test score[10] (e.g., fluency total score was calculated by summing the semantic fluency score and phonemic fluency score). More details on the tests and variables used to calculate normative data are provided in Table 1.

Percentile norms were derived for the tests of the COGNITO battery for each age group and literacy category. The 5th, 10th, 25th, 50th, and 75th percentiles were calculated. Statistical analysis was conducted by using SPSS version 23.0.

3 | RESULTS

COGNITO norms were calculated for a sample of 1400 participants from rural India. Table 2 shows the demographic characteristics of the participants, wherein 52.77% of the sample population are females. The mean age of the sample is 57.75 years (standard deviation [SD] = 9.99) and the mean years of education is 4.53 years (SD = 4.69). Illiterates comprised 46.59% of this sample, of which 76% are females. Literate individuals comprised 40.83% of the sample (mean years of

TABLE 1 Tests comprising attention, language, memory, visuospatial abilities cognitive domains in COGNITO, and the outcome variable used for derivation of normative scores

Test	Variable used	Maximum score possible
Attention		
Reaction time (RT)	Mean RT	500 ms
Auditory attention	Total correct answers	10
Visual attention	Total correct answers	10
Dual attention	Total correct answers	10
Language		
Comprehension	Total correct answers	5
Phoneme comprehension	Total correct answers	10
Naming	Total correct answers	10
Associations	Total correct answers	10
Fluency	Total correct answers (phonemic + semantic)	No maximum score limit as score is based on the number of correct responses given by participant
Vocabulary*	Total correct answers	35
Memory		
Names immediate recall	Total correct answers	9
Names delayed recall	Total correct answers	9
Names recognition	Total correct answers	18
Name-face association: names	Total correct answers	9
Name-face association: faces	Total correct answers	18
Implicit memory*,#	Average number of frames taken to identify the name by total number of frames* 10	–
Visuo-spatial abilities		
Stroop test*	Total errors	45
Visuo-spatial span	Total span	9
Geometric figures	Total correct answers	8
Matrices	Total correct answers	30
Construction (drawing)*	Total correct elements (House + Abstract)	80 (40 + 40)

*Test not administered to the Illiterate group as it involved reading or drawing with the use of a pencil.
#Score for this test was calculated based on the number of frames the participant took to identify the name (stimuli) divided by the total number of frames possible multiplied by the number of trials (10). Based on these calculations, a lower score would indicate better performance on the implicit memory test.

education = 9.30, SD = 2.83), and 12.56% of participants belonged to either the semi- or functional literate category (mean years of education = 4.50, SD = 2.23); 73.13% of participants who belonged to the literate category were males. The 45 to 54 age range makes up 42.5% of the sample, 29.02% belonged to the 55 to 64 age range, 20.55% belonged to the 65 to 74 range, and 7.92% of the sample was 75 years and above. Males constituted 47.22% of the total sample.

The normative data for the tests in the COGNITO battery under the domains of attention, language, memory, and visuo-spatial processing are shown in, respectively, Tables S1A, S1B, S1C, S1D in supporting information. Norms are presented for the three literacy categories (literates, illiterates, and semi- or functional literates) within the four age groups (45–54, 55–64, 65–74, and 75 years and above). The sample size differs across tests because of participants not completing the tests due to reading or writing constraints or difficulties in comprehending certain tasks. For each test, participants with missing data were excluded, after which the normative data for the sample was computed. Normative data for Stroop, vocabulary, implicit memory, and visuospatial construction are not provided for illiterates as these tests were not administered to them.

The 5th percentile corresponds to the threshold under which 5% of participants have the lowest performances and the 75th percentile is the threshold above which 25% of participants have the best performances. Tables S1A, S1B, S1C, S1D and Figures 1A-D, 2A-F, 3A-F, 4A-E clearly depict that the normative scores are the highest for the literate category across all age groups, the semi-literates have an intermediate score, and the illiterate individuals have the least scores—a pattern observed for most of the cognitive tests in each of the domains. Note

TABLE 2 Sociodemographic characteristics of the study sample in the Srinivaspura Aging, Neuro Senescence and Cognition study

Characteristic	N (%)	Mean (in years)	Standard deviation (in years)
Age (in years)			
45-54	612 (42.5)	48.33	2.76
55-64	418 (29.02)	58.93	2.79
65-74	296 (20.55)	67.60	2.68
75+	114 (7.92)	78.37	3.90
Total	1440	57.75	9.99
Literacy group[a]			
Literate	588 (40.83)	9.30	2.83
Illiterate	671 (46.59)	0.36	1.23
Semi- or functional literate	181 (12.56)	4.50	2.23
Sex			
Males	680 (47.22)	–	-
Females	760 (52.77)	-	-

[a]For literacy group, the mean and standard deviation is represented in number of years.

here that for tests' reaction time, for Stroop C and Implicit Memory, a lower score is indicative of better performance. Therefore, the 5th percentile for these two tests corresponds to the lowest performing individuals but shows a higher normative data, and the 75th percentile normative score is showing a greater value but indicates the higher performers in these tests.

These results from the current study dataset across three different literacy groups suggest cognitive abilities are highest in literate, least in illiterate, and intermediate in semi/functionally literate individuals. The percentile scores for the cognitive tests show a decline for the individuals aged 75 years and above, indicating lower cognitive functioning in this age group.

4 | DISCUSSION

The present study aimed at developing normative data for the COGNITO battery with a large sample of aging adults from the ongoing SANSCOG study—a prospective, community-based, cohort study that focuses on understanding the risk and protective factors associated with normal as well as pathological aging. This is significant because literacy and level of education have been consistently found to influence cognitive performance on neuropsychological assessments, leading

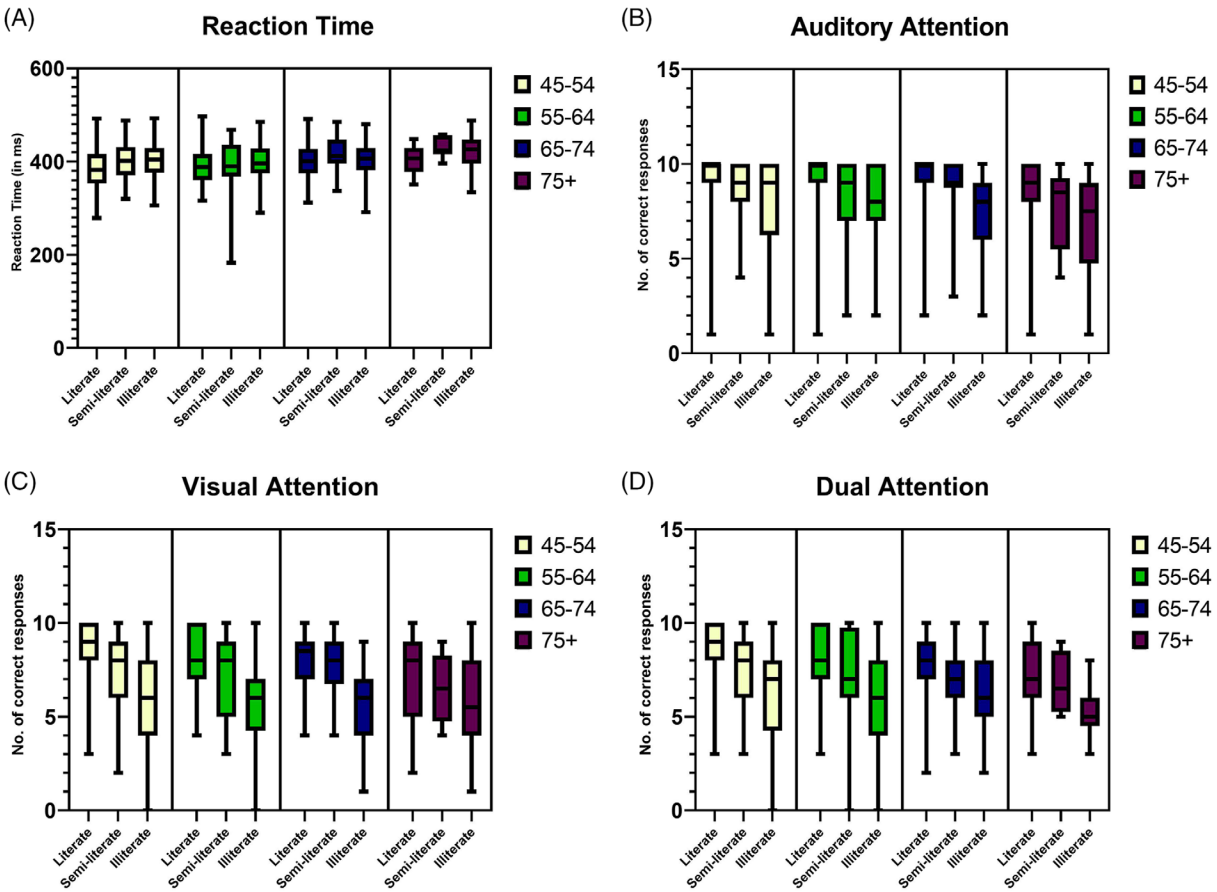

FIGURE 1 Box plot representation of normative scores for cognitive domain "attention" for tests: (A) reaction time, (B) auditory attention, (C) visual attention, (D) dual attention, in different age and literacy categories for 1440 individuals in the Srinivaspura Aging, Neuro Senescence and Cognition study population

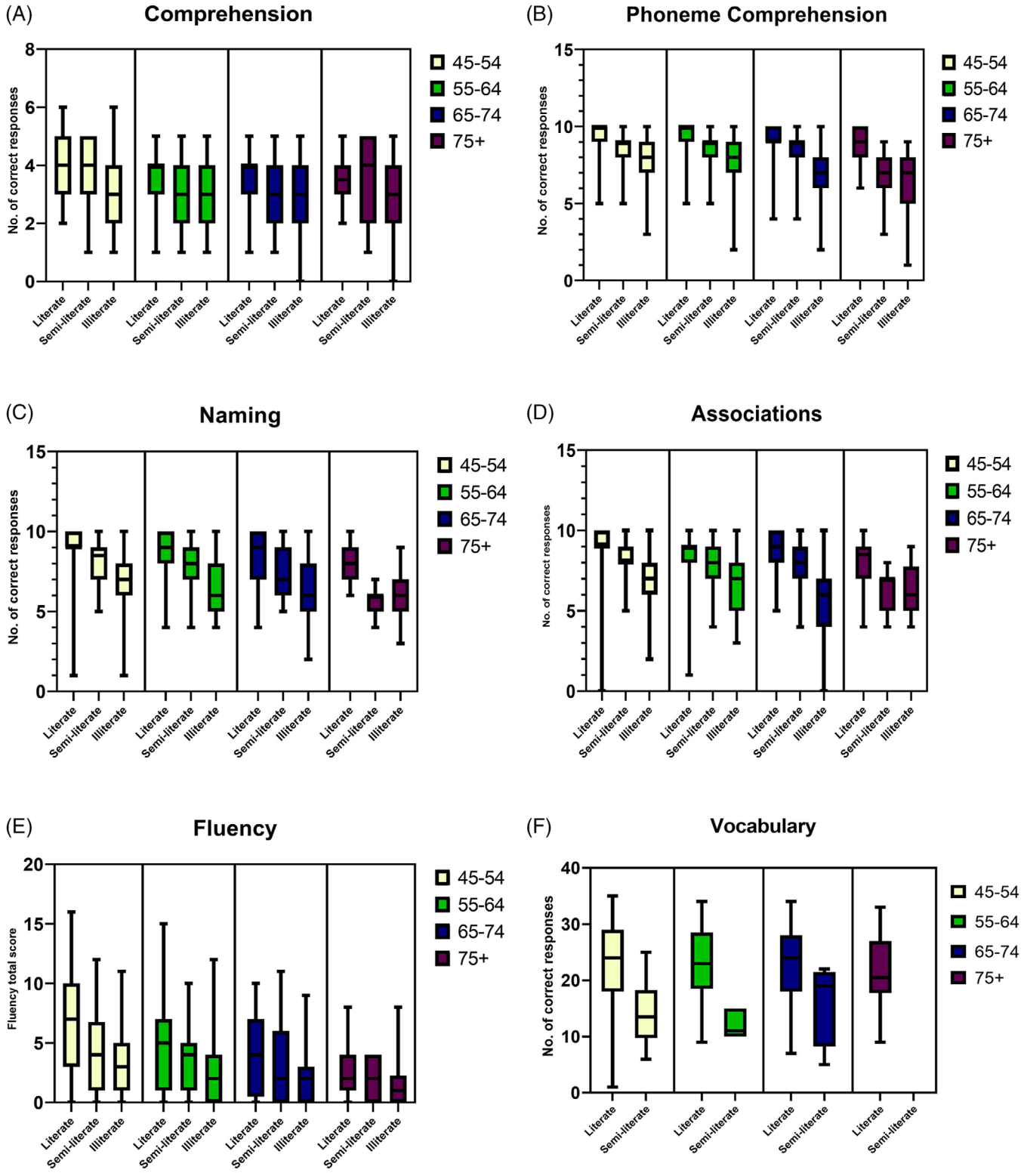

FIGURE 2 Box plot representation of normative scores for cognitive domain "language" for tests: (A) comprehension, (B) phoneme comprehension, (C) naming, (D) associations, (E) fluency, (F) vocabulary, in different age and literacy categories for 1440 individuals in the Srinivaspura Aging, Neuro Senescence and Cognition study population

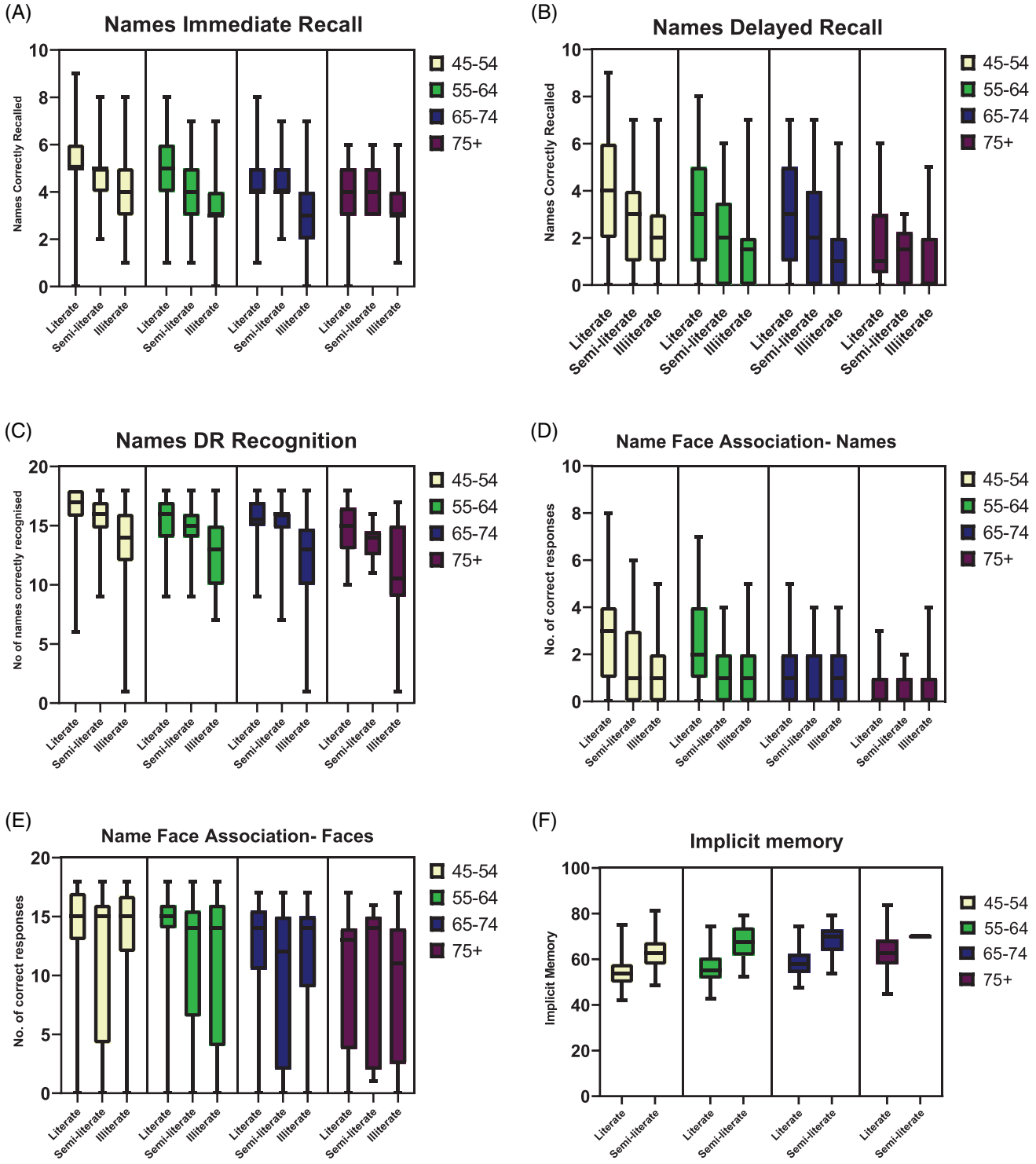

FIGURE 3 Box plot representation of normative scores for cognitive domain "memory" for tests: (A) names immediate recall (B) names delayed recall, (C) names delayed recall recognition, (D) name–face associations names, (E) name–face associations faces, (F) implicit memory, in different age and literacy categories for 1440 individuals in the Srinivaspura Aging, Neuro Senescence and Cognition study population

cognitively normal older adults to be misclassified as being cognitively impaired.[13] As longitudinal epidemiological studies require the use of a sensitive battery to assess neurocognitive functioning, it is vital to develop normative data specific to the cultural and educational background of the population under study.

In the current article, we have presented normative data for the tests in COGNITO battery, which was adapted to suit the language and culture of the study population. These norms have been computed for a sample of 1440 cognitively normal individuals living in rural India in different age and literacy categories. We observed that the scores

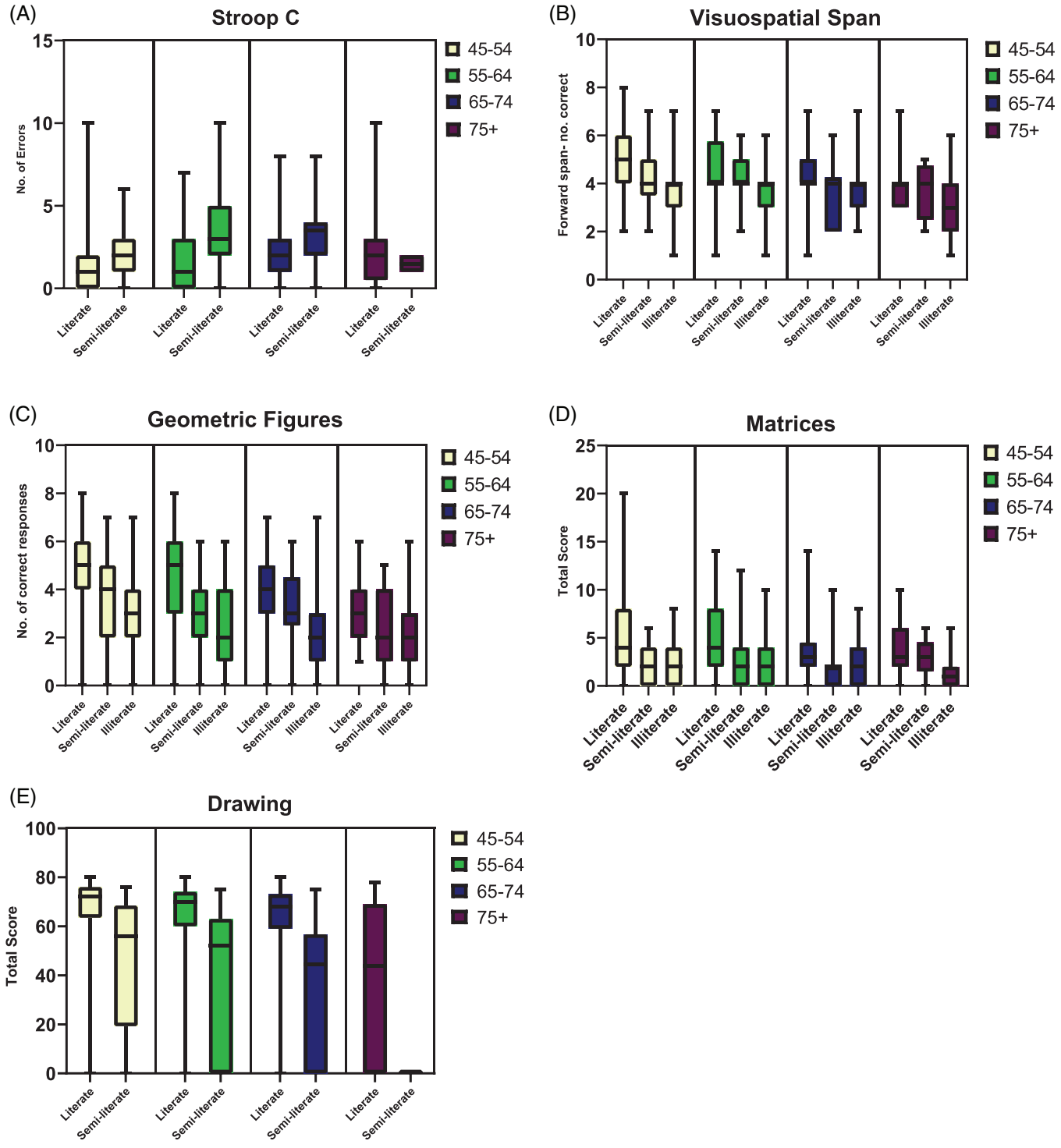

FIGURE 4 Box plot representation of normative scores for cognitive domain "visuospatial abilities" for tests: (A) Stroop C, (B) visuospatial span, (C) geometric figures, (D) matrices, (E) drawing in different age and literacy categories for 1440 individuals in the Srinivaspura Aging, Neuro Senescence and Cognition study population

for most of the cognitive tests in each of the domains are the highest (lowest for reaction time, Stroop C and Implicit memory, wherein a lower score is indicative of better performance) for the literate category across all age groups, and lowest for the illiterate individuals, with the semi-literates having an intermediate score. The percentile scores for the cognitive tests show a decline for the individuals aged 75 years and above, indicating lower cognitive functioning in this group of individuals (Tables S1A, S1B, S1C, S1D and Figures 1A-D, 2A-F, 3A-F, 4A-E).

The strengths of this study lie in the large sample size analyzed to calculate the normative data. Classification of individuals into various

literacy categories in this study addresses a significant lacuna as data from illiterate or less literate population, which is pertinent to India and other developing countries, is scarce. The work carried out in this study based on the individuals' functional literacy abilities provides us with norms for individuals across the spectrum of literacy, which is highly valuable in a country such as India, which has such unique diversity in terms of its language, education, socio-economic status, and rural–urban ratio.[22]

This study has certain limitations. The mean age of the participants was 57.75 years. The number of participants in the older age groups was lower, and hence individuals were grouped into one category for 75 years and above for normative data calculation. As the proportion of the population constituting the age group of 80 years and above are increasing worldwide,[23] and with age being one of the highest risk factors for the development of dementia,[24,25] the norms for this population will require modification as the population ages or as the number of participants in the > 80 years age "oldest old" category recruited into the study increases. Additionally, future longitudinal data of the COGNITO battery from our study will help to understand the mechanisms underlying the decline of cognitive activity with old age, and how cognitive functioning is maintained in otherwise healthy individuals in this cohort.

The norms provided in this paper will help facilitate the study of cognitive functioning in a large sample of individuals ranging from literate and low literacy to illiterate participants with a wide variety of cognitive assessments under four principal cognitive domains: attention, memory, language, and visuospatial abilities. Such normative data will be of great value as a reference panel to clinicians and researchers alike who are interested in studying and assessing cognitive functioning for identifying cognitively healthy and impaired individuals; as well as studying cognitive changes in populations with varied levels of literacy, especially in the low literacy and illiterate individuals living in rural areas constituting a major mass of population in India and developing nations.

AUTHOR CONTRIBUTIONS

The SANSCOG team led by Vijayalakshmi Ravindranath conceptualized and designed the SANSCOG study. Bratati Kahali and Graciela Muniz-Terrera designed the analysis reported in this paper. Karen Ritchie helped with initial administration of COGNITO in the SANSCOG study. Acquisition of data was done by Aditi Balakrishnan and Sneha Dhanavanthri Muralidhara. Analysis was done by Aditi Balakrishnan, Sneha Dhanavanthri Muralidhara, and Bratati Kahali; and interpretation of data was done by Bratati Kahali and Graciela Muniz-Terrera. Drafting the manuscript along with figures and tables was by Aditi Balakrishnan, Sneha Dhanavanthri Muralidhara, Bratati Kahali, and Vijayalakshmi Ravindranath and Graciela Muniz-Terrera gave critical suggestions on the draft. All authors approved the final version of the manuscript for publication.

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CONFLICTS OF INTEREST

The authors have no conflicts, whether personal, financial, or otherwise.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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APPENDIX A

Collaborators

SANSCOG STUDY TEAM

List of Collaborators—arranged in alphabetical order.

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