International Psychogeriatrics, Vol. 8, No. 4, 1996

Studies on Cognition and Dementia

Cognitive Test Performance in a Community-Based Nondemented Elderly Sample in Rural India: The Indo-U.S. Cross-National Dementia Epidemiology Study

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ABSTRACT. Interpretation of cognitive test performance among individuals from a given population requires an understanding of cognitive norms in that population. Little is known about normative test performance among elderly illiterate non-English-speaking individuals. An age-stratified random sample of men and women, aged 55 years and older, was drawn from a community-based population in the rural area of Ballabgarh in northern India. These Hindi-speaking individuals had little or no education and were largely illiterate. A battery of neuropsychological tests, specially adapted from the CERAD neuropsychological battery, which was administered to this sample, is described. Subjects also underwent a protocol diagnostic examination for dementia. Norms for test performance of 374 nondemented subjects on these tests are reported across the sample and also by age, gender, and literacy.

Cognitive impairment, the hallmark of dementia, is detected subjectively from historical information offered by patients and other informants, and from the clinician's observations of general mental status. Objective assessment requires

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the clinician to measure the individual's performance on one or more cognitive (neuropsychological) tests on one or more occasions. Interpretation of these measurements as being within or outside the normal range requires prior knowledge of the normal range for the population to which the individual belongs. Normative values on standardized cognitive tests are becoming increasingly available for westernized, predominantly Anglophone populations in industrialized countries. Norms are much less readily available for the populations of non-English-speaking developing societies, particularly where those populations have little education. Indeed, standardized cognitive tests barely exist for such populations.

The need for tests appropriate to the culture and educational level of the population to be tested has been discussed previously (Chandra et al., 1994; Escobar et al., 1986; Ganguli et al., 1995; Graves et al., 1994; Hall et al., 1993). If neuropsychological test scores are to be used to detect the presence of dementia, and to measure its severity, it is essential to distinguish the effects of dementia on test performance from the preexisting and independent effects of culture, language, and education (White, 1989). No test is completely "culture-free"; at best, it can be relatively "culture-fair" and it can avoid penalizing members of one culture for poor performance on tests designed for, and standardized on, members of another. Culturally relevant factors can include comprehensibility, acceptability, perceived relevance of test content, fluency in the language, and familiarity with testing situations, concepts, procedures, and materials.

In preparation for an epidemiological study of dementia in a rural community in northern India, we developed a battery of cognitive tests to screen for and characterize dementing illness among the elderly in that community. In this article, we describe the test battery and report normative scores on these tests from a population-based sample of elderly individuals identified as nondemented.

METHODS

Background

The Indo-U.S. Cross-National Dementia Epidemiology Study is a collaborative project of the University of Pittsburgh in Pittsburgh, and the Centre for Ageing Research, India (CARI), in New Delhi. Its two primary goals are to investigate the epidemiology of the dementing disorders among the elderly in the rural district of Ballabgarh in northern India, and to compare the results with those being obtained from the Monongahela Valley Independent Elders Survey (MoVIES project) (Ganguli et al., 1993), an ongoing study in a rural community in Pennsylvania (U.S.A.). The study is funded by a National Institute on Aging program in the expectation that epidemiological similarities and differences will help identify new risk factors for dementia (National Institute on Aging, 1988). The first step of the cross-national study was to develop, for the

Ballabgarh elderly, an appropriate cognitive screening battery that would be psychometrically sound, reliable and valid, suffer from minimal cultural and educational biases, have optimal sensitivity and specificity for dementia, and, eventually, allow meaningful comparisons to be made between the two populations. A considerable challenge was posed by the fact that the Ballabgarh population was exclusively Hindi-speaking and of rural northern Indian culture, poorly educated, and largely illiterate. In developing the Hindi battery, we reasoned that the cognitive variables on which comparisons were to be made between Indian and American populations had to have similar meanings and be susceptible to similar interpretations in the groups being compared. Thus, we had to first identify the important underlying dimensions on which the populations were to be compared, and then find ways of assessing them that were appropriate to the groups being compared, rather than concentrating on superficial similarity of method (Chandra et al., 1994; Ganguli et al., 1995).

Test Development

The Hindi cognitive tests were based on the English cognitive screening panel used by the MoVIES project (Ganguli et al., 1991), which incorporates the neuropsychological battery developed by the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) (Morris et al., 1989). This battery includes a brief global cognitive scale or general mental status test, the Mini-Mental State Examination (MMSE) (Folstein et al., 1975), and a set of other tests tapping several specific cognitive domains known to be affected by the dementias of late life. The original CERAD battery included a set of memory tests (learning, recall, and delayed recognition of a 10-item word list) (Atkinson & Shiffrin, 1971), verbal fluency tests (initial letters P and S, and categories of fruits and animals) (Benton & Hamsher, 1976), confrontation naming (Boston Naming Test, 15-item version) (Kaplan et al., 1983; Morris et al., 1989), and tests of constructional praxis (copying of four line-diagrams) (Rosen et al., 1984). In addition, the MoVIES battery also includes a test of logical memory (immediate retelling and delayed recall of an 18-item story) (Becker et al., 1987), a test of executive functions and constructional ability (Draw A Clock) (Freedman et al., 1994), the Temporal Orientation Test (Benton et al., 1982), and tests involving visual scanning, sequencing, speed, working memory, and maintenance of set (Trailmaking Tests A and B) (Reitan, 1955).

Using the example of the MMSE, we have previously described in detail the multiple stages of Hindi test development that led to the final version, known as the Hindi Mental State Exam (HMSE) (Ganguli et al., 1995). Each of the other tests in the final cognitive screening battery, described in this article, is the product of the same stages, namely consensus development, translation and back-translation, iterative pretesting on successive groups of 30 elderly volunteers each, pilot testing on a random sample of 100 elderly individuals, and, finally, field testing on an age-stratified random sample of almost 400 elderly persons from the target population. Examination of data collected at each stage led to appropriate modifications of the tests that were further examined during the next stage. Our overall goal was to develop versions of the tests that were comprehensible and acceptable to the local population, appeared to tap the desired cognitive domain(s), did not have significant floor or ceiling effects, and had distributions of scores comparable to those found among nondemented individuals in the reference MoVIES population. The majority of tests used in the MoVIES project were found to be amenable to translation and adaptation for the local culture, some requiring more modification than others. A few tests, after consideration and pretesting, were discarded after we determined that they would not survive adaptation and still meaningfully assess the cognitive function(s) of interest in the Ballabgarh population. A detailed training and operations manual was also prepared to ensure the reliable administration of the tests by appropriately trained lay field workers. A brief description of the final battery of tests follows.

Hindi Mental State Examination. Our Hindi adaptation of the MMSE (Folstein et al., 1975) has been described in detail elsewhere (Ganguli et al., 1995). The major differences from the original were in (a) orientation to the year (a piece of information that did not appear to be common among or relevant to these illiterate rural elderly), and for which we substituted "time of day;" (b) the attention subtest requiring serial subtractions in the abstract, for which we substituted a story requiring serial subtractions; (c) the attention subtest requiring spelling the word "WORLD" backwards, for which we substituted the task of naming the days of the week backwards; (d) the "write a sentence" subtest, for which we substituted an oral task, "tell me something about your house;" and (e) the praxis task (copying intersecting pentagons), for which we substituted a simpler drawing of a diamond shape within a square. The HMSE total score was calculated using the "days of the week" attention subtest, while the calculation task was scored separately. Alternatively, the HMSE score can be totaled substituting the calculation task for the "days" task as the attention subtest.

Word List Learning, Recall, and Delayed Recognition Tests (Atkinson & Shiffrin, 1971). In the English-language version, the subject reads a list of 10 words and then attempts to recall them. There are three learning trials followed by delayed recall and recognition trials. In the recognition trials, subjects are presented with a list of 20 words, including the 10 original words and 10 foils. The task is to correctly classify each word as having been present on the original list ("originals") or not ("foils"). Because of the high level of illiteracy in the population, we used the same format but with auditory presentation and with words that appeared to us (in the absence of formal word frequency norms for Hindi) to be roughly equivalent in terms of familiarity, concreteness, and imageability. The Hindi word list consists of the Hindi words for butter, arm, corner, letter, queen, ticket, grass, stone, book, and stick.

With auditory presentation, subjects appeared to be confused as to which "words" they were being asked to repeat on delayed recall. To minimize source amnesia and help subjects distinguish these "words" from other "words" mentioned during testing (e.g., the three orally presented words for recall on the HMSE), a cueing strategy was devised. The word list was typed on a sheet of green paper, which is held up prominently during initial administration; the oral instructions for learning, recall, and recognition always refer to the "words on the green paper." With this cue, subjects appeared to understand the task more readily and their scores improved.

Object Naming Test. MoVIES uses CERAD's 15-item version (Morris et al., 1989) of the Boston Naming Test (Kaplan et al., 1983) in which subjects are asked to name objects represented as line drawings. The objects in the parent test were first considered for intuitive appropriateness for the Ballabgarh population, and substitutions made where necessary; for example, we did not expect this population to be able to identify drawings of a volcano or dominoes. Additional words were added in all three categories (high, medium, and low frequency) of the list so that we could pretest and choose among more words than we would eventually use. Each object was redrawn by a local artist so as to conform to locally familiar forms of the objects. Extensive testing and redrawing led us to suspect that our many rural uneducated subjects had little if any familiarity with drawings and other two-dimensional representations of three-dimensional objects. This hypothesis was tested in a substudy using a balanced order experiment with three groups of elderly volunteers, and three types of stimuli presented at 1-week intervals. The stimuli were three-dimensional objects (models), photographs of the same objects, and line drawings copied from the photographs. Subjects had significantly more difficulty in recognizing the drawings than in recognizing the objects. We concluded that the use of objects, rather than of drawings, was the better test of lexical access for this population and similar enough to the MoVIES/CERAD task to legitimize comparisons. The objects are models of a flower, a lock, a bottle, an elephant, a rolling pin, a syringe, a comb, a pair of scissors, a pair of spectacles, a basket, a flute, an aircraft, a funnel, a telephone, and a necklace.

Verbal Fluency (Benton & Hamsher, 1976). The subject is required to list, in a given category, as many items as possible in 60 seconds. In the MoVIES project, verbal fluency is tested both for words beginning with certain initial letters (P and S) and for words in certain categories (fruits and animals). Because the majority of our Indian subjects were illiterate, we asked them to name words beginning with the corresponding sounds (phonemes), rather than letters. We found that, although subjects were able to list fruits and animals with relative ease, they were almost unable to perform the fluency task for phonemes. In a substudy using younger subjects with zero, 5th, and 10th grade education, there was a clear effect of education on performance on both the initial phoneme and the category fluency tasks, but also a significant interaction between education and task, i.e., initial letter fluency was more strongly influenced by education than was category fluency (Chandra et al., 1993). We concluded that initial letter/phoneme fluency was not an appropriate test for illiterate subjects and have retained only category fluency in the current cognitive battery. In this article, we report fluency data for "fruit" and "animal" categories separately, to allow comparisons with other studies; however, for screening purposes, our study uses the combined total as a single fluency test score.

Praxis/Simple Construction (Rosen et al., 1984). In this test, the subject is required to copy four line drawings of a circle, diamond, a cross (intersecting rectangles), and a cube. This test, like the MMSE figure-copying task, was extraordinarily difficult for subjects who had never held pencil to paper, despite remarkable efforts on their parts. Given the awkwardness with which many of them held the pencil, and the general unfamiliarity of the task, we developed more liberal scoring criteria than would be acceptable in MoVIES or CERAD. The circle, diamond, and cross were at least marginally reproducible by Ballabgarh elderly. However, subjects had particular difficulty perceiving the cube as a three-dimensional object, and appeared to be trying to copy it as an irregular hexagon with various intersecting diagonals. We simplified the figure so that it resembled the inside of a box viewed from above, with no intersecting lines. We also developed a scoring system similar to that used in MoVIES (and CERAD), with prototype drawings to guide scoring.

Eliminated Tests. As noted, initial letter/phoneme fluency tests were discarded from the final battery. The Temporal Orientation Test was eliminated because scores were at floor. The Trailmaking Tests were also dropped after unsuccessful efforts to adapt them, because subjects were unfamiliar with both alphabetical and numerical characters required to maintain the sequence. Tests of logical memory (retelling and recall of a story) also had to be dropped. Multiple attempts were made to adapt this task for this population, including reformating it in short declamatory sentences such as are used in the Indian storytelling tradition, and substituting a new, more "exciting" story with traditional themes. However, the population's performance remained at floor, providing insufficient variance for this test to serve as an efficient screening device.

Because the elderly members of this community were unable to draw clocks, we originally substituted the task of drawing another symmetrical object, a human face. The population's lack of drawing experience led the majority of face-drawings to be difficult to score; a subgroup of women substituted an overlearned, stylized drawing of a human female figure, traditionally used to decorate the walls of their homes. The free-drawing test was also eliminated from the final battery.

Study Population

The rural district of Ballabgarh in the State of Haryana, in northern India, is approximately 35 km from New Delhi and consists of 28 villages. The population follows largely agricultural occupations, and most of its currently elderly members, particularly the women, are illiterate. The community is the field-practice site of the Centre for Community Medicine of the All-India Institute of Medical Sciences, which operates a Comprehensive Rural Health Services Project in the area. The project has, for over two decades, maintained an up-to-date census of the entire population of Ballabgarh. We were given access to this census for the purpose of identifying the older residents of the area and inviting their participation in our study. From the approximately 4,800 individuals originally identified in the census database as being 55 years or older, a 10% age-stratified sample of 480 persons was drawn, to include 160 subjects in each age category 55-64, 65-74, and 75+ years. Field workers visited each subject at home and obtained informed consent according to procedures approved by the CARI Human Volunteers Protection Committee and the University of Pittsburgh Institutional Review Board. As part of demographic data-gathering, age as recorded in the database was confirmed with the subject. When, as is often the case in rural areas of developing countries, an elderly subject was unaware of his exact age or date of birth, age was confirmed by asking the subject and family to estimate his/her age at the time of well-known historic events (Rajkumar and Kumar, 1996). Among the 480 persons, 8 were determined to be less than 55 years old, 53 had died, 22 had relocated outside the study area, 1 was a duplicate listing, 8 refused cognitive testing, and 1 was cognitively untestable. Field testing was carried out among the remaining 387 individuals who were administered the aforementioned cognitive tests.

Data Collection

Consenting subjects were cognitively screened by trained lay field workers under the supervision of the project neuropsychologist (S.S.) and medical officer (R.P.). All consenting subjects were also independently examined by the project neurologist (V.C.) and medical officer (R.P.) to determine the presence or absence of a dementia syndrome according to criteria of the *Diagnostic and Statistical Manual of Mental Disorders,* Third Edition, Revised (DSM-III-R; American Psychiatric Association, 1987), using a standardized diagnostic protocol consisting of a semistructured, detailed history from the subject and his/her next-of-kin, general physical and neurological examinations, and further mental status examination (modified from the MoVIES and CERAD protocols) (Ganguli et al., 1993; Morris et al., 1989). The protocol includes the Clinical Dementia Rating (CDR) scale (Hughes et al., 1982), according to the CERAD (Morris et al., 1989) guidelines, which were found to be applicable without modification to the Indian population because they are based entirely on reports and observation of the cognitive aspects of daily functioning. Two subjects (one of whom had been cognitively untestable) were diagnosed as demented with CDR scores of 4. Twelve subjects did not undergo diagnostic evaluation (5 refused, the family of 1 refused although the subject was in good health, the family of 1 refused because the subject was too ill and blind, 2 relocated, and 3 who were gainfully employed did not have time to participate). The remaining 374 individuals were determined by the diagnostic protocol to be free of dementia, with CDR scores of 0. The data presented here are from these nondemented subjects and may therefore be considered to represent healthy norms.

RESULTS

Demographic Characteristics

Of the 374 nondemented individuals constituting the sample reported here, 120, 140, and 114 were aged 55-64 years, 65-74 years, and 75+ years respectively. Men and women constituted 53.5% and 46.5% respectively, consistent with the gender ratio of the base population. Some literacy, defined as the ability to both read and write, was reported by 81 (21.7%) of the subjects; the rest were classified as illiterate. Of those aged 75 years or more, 82.5% had no literacy, as compared to 76.5% of those aged less than 75 years. Among women, 94.8% were illiterate, as compared to 64.0% of men. The majority of the population of the rural district of Ballabgarh, 35 km from New Delhi, follows agricultural occupations.

Figures 1 through 11 show the overall distribution of scores for each subtest of the cognitive test battery. Tables 1 through 3 show norms for the entire test battery, which may be useful for others wishing to use or adapt these tests for other studies. For each cognitive test, Table 1 shows the observed ranges, means and standard deviations, and 10th and 50th (median) percentile scores for the

```
                 HMSE Total

              Histogram                  #
30 | ********************               40
29 | ****************************       56
28 | ************************           48
27 | ************************           47
26 | ********************               40
25 | *********                          18
24 | *************                      26
23 | **********                         19
22 | ******                             12
21 | *******                            13
20 | *********                          17
19 | *****                               9
18 | *****                               9
17 | ****                                8
16 | **                                  4
15 | **                                  3
14 | **                                  4
13 | *                                   1
   ----------------------------------
   * may represent up to 2 counts
```

Figure 1. Overall distribution of total scores on HMSE Test.

```
               HMSE Calculation

                 Histogram                      #
5 | *********************************          97
4 | *******************************            92
3 | **************                             40
2 | ****************                           48
1 | ************                               36
0 | ***********                                33
  ----------------------------------------
  * may represent up to 3 counts
```

Figure 2. Overall distribution of scores on HMSE Calculation Subtest.

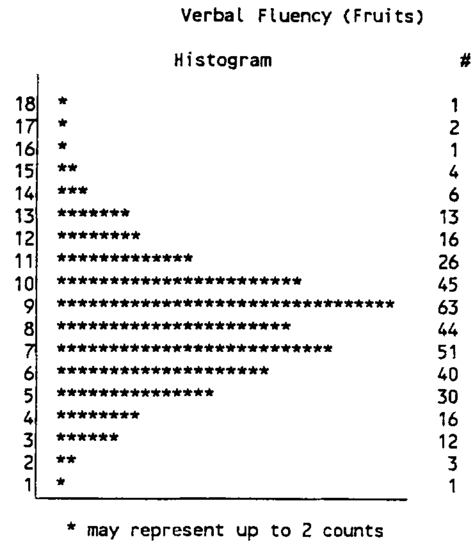

Figure 3. Overall distribution of scores on Verbal Fluency (Fruits) Subtest.

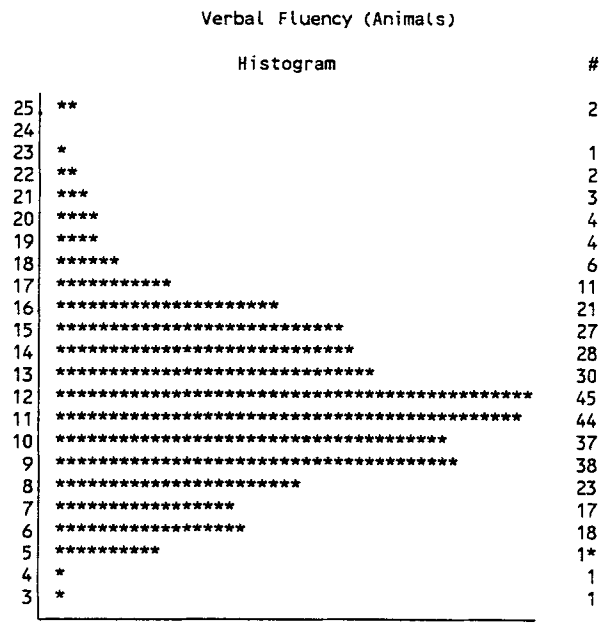

Figure 4. Overall distribution of scores on Verbal Fluency (Animals) Subtest.

entire nondemented sample. Table 2 shows the 10th and 50th percentile scores, means, and standard deviations within age groups; Table 3, within gender groups and literacy subgroups. As is usually the case in community studies, the sample size differs slightly across tests because some subjects did not complete all the tests. In most cases, subjects were unable to complete one or more tests because of severe visual or auditory impairment; occasionally a subject complained of fatigue and did not or would not complete a particular test.

```
Variable=VERBALCT        Verbal Fluency (Fruits and Animals)

                    Histogram                  #

      39 | *                                   2
      37 |
      35 | ***                                 5
      33 | ***                                 6
      31 | ***                                 6
      29 | ******                             12
      27 | *********                          18
      25 | *********************              42
      23 | **************************         52
      21 | *************************          50
      19 | ****************************       56
      17 | **********************             44
      15 | ***************                    30
      13 | **************                     28
      11 | ********                           16
       9 | **                                  4
       7 | *                                   1
       5 | *                                   1
         +--------------------------------
        * may represent up to 2 counts
```

Figure 5. Overall distribution of scores on Verbal Fluency (Fruits and Animals) Subtests.

```
                         Object Naming

                           Histogram                                #

   |
15 |  ***********************************************             235
14 |  *****************                                            81
13 |  ******                                                       28
12 |  **                                                           10
11 |  *                                                             3
10 |  *                                                             2
 9 |  *                                                             1
 8 |  *                                                             1
 7 |  *                                                             1
   +--------------------------------------------------
      * may represent up to 5 counts
```

Figure 6. Overall distribution of scores on Object Naming Test.

```
                      Constructional Praxis

                    Histogram                        #
    |
12  |  *******************************               62
11  |  ***************************                   54
10  |  *****************************                 58
 9  |  ****************                              31
 8  |  **********************                        43
 7  |  ***********                                   22
 6  |  *************                                 26
 5  |  *********                                     18
 4  |  ***                                            6
 3  |  ******                                        11
 2  |  ******                                        11
 1  |  *******                                       13
 0  |  *                                              2
    +-------------------------------------
       * may represent up to 2 counts
```

Figure 7. Overall distribution of scores on Constructional Praxis Test.

```
                    Word List Learning

                          Histogram                    #

24 | *****                                             5
23 | *********                                         9
22 | ****                                              4
21 | ***************                                  15
20 | ****************                                 16
19 | *************************                        25
18 | **************************                       26
17 | ********************************                 32
16 | ***********************************              35
15 | **********************************               34
14 | *************************                        25
13 | ********************************                 32
12 | *********************************                33
11 | **************************                       26
10 | *********************                            21
 9 | **************                                   14
 8 | *******                                           7
 7 | ****                                              4
 6 | ***                                               3
 5 | *                                                 1
 4 | **                                                2
 3 | *                                                 1
   +----------------------------------------
```

Figure 8. Overall distribution of scores on Word List Learning Test.

```
                    Word List Recall

                       Histogram                          #

10 | **                                                   4
 9 | *****                                                9
 8 | ***************                                     29
 7 | *********************                               42
 6 | *************************                           49
 5 | **********************************                  68
 4 | **************************************              75
 3 | **********************                              44
 2 | ***********                                         21
 1 | *******                                             14
 0 | ********                                            15
   +------------------------------------------
      * may represent up to 2 counts
```

Figure 9. Overall distribution of scores on Word List Recall Test.

```
                      Word List Recognition (Correct)

                          Histogram                              #

10 | *********************************************             222
 9 | ************                                               60
 8 | *********                                                  45
 7 | *****                                                      24
 6 | **                                                         10
 5 | *                                                           5
 4 | *                                                           2
 3 | *                                                           1
 2 | *                                                           1
   +-------------------------------------------------
      * may represent up to 5 counts
```

Figure 10. Overall distribution of scores on Word List Delayed Recognition (Originals) Test.

```
        Word List Recognition (Incorrect)

                   Histogram                          #

10 | ********************************************   213
 9 | *************                                   64
 8 | *******                                         35
 7 | ****                                            17
 6 | ***                                             13
 5 | *                                                2
 4 | *                                                5
 3 | **                                               6
 2 |
 1 | *                                                5
 0 | **                                              10
   ----------------------------------------------
     * may represent up to 5 counts
```

Figure 11. Overall distribution of scores on Word List Delayed Recognition (Foils) Test.

TABLE 1. Overall Distribution of Test Scores (Nondemented Sample, n = 374)

Test	n[a]	Observed Range	Mean (SD)	Median	10th Percentile Score
HMSE Total	374	13–30	25.4 (4.0)	27	19
HMSE Calculation	346	0–5	3.2 (1.7)	4	0
Verbal fluency					
Fruits	374	1–18	8.2 (2.8)	8	4
Animals	373	3–25	11.7 (3.7)	11	6
Fruits + animals	373	5–38	19.9 (5.6)	20	12
Object naming	362	7–15	14.4 (1.1)	15	13
Constructional praxis	357	0–12	8.5 (3.1)	9	3
Word list learning	370	3–24	14.9 (4.1)	15	9
Word list recall	370	0–10	4.8 (2.2)	5	1
Word list recognition					
Originals	370	2–10	9.2 (1.3)	10	7
Foils	370	0–10	8.7 (2.3)	10	6

Note. HMSE = Hindi Mental State Exam.
[a]Sample size is less than 374 for some tests because some subjects did not complete all tests.

DISCUSSION

Culture and the Measurement of Cognitive Functioning

Cognitive functioning is a product primarily of brain structure and physiology, which are assumed not to vary among populations. However, cognitive performance is also derived from knowledge base, acquired skills, etc., which are clearly influenced by culture and education. It is therefore difficult to measure "brain functioning" independently of the effects of culture and education. Tests of general and specific cognitive functioning that are standardized in, and appropriate for, members of one culture may be inappropriate, in form or content or both, for another culture. Thus, the form and content of the modified task should be selected primarily based on the scope of the cognitive function(s) being measured. Floor effects can affect the usefulness of the test as a screening tool for dementia; ceiling effects may not affect screening but can hinder the

TABLE 2. Distribution of Test Scores by Age (Nondemented Sample, $n = 374$)

		Age (years)								
		55–64 $n = 120$			65–74 $n = 140$			75–93 $n = 114$		
Test	n^a	Mean (*SD*)	Median	10th Percentile	Mean (*SD*)	Median	10th Percentile	Mean (*SD*)	Median	10th Percentile
HMSE Total	374	26.3 (3.0)	27	21	25.6 (4.1)	27	18	24.3 (4.4)	26	17
HMSE Calculation	346	3.2 (1.7)	4	0	3.5 (1.6)	4	0	2.9 (1.7)	3	0
Verbal fluency										
Fruits	374	8.8 (2.7)	9	5	8.3 (2.7)	8	5	7.7 (3.0)	8	3
Animals	373	11.9 (3.4)	11.5	8	12.3 (3.9)	12	7	10.7 (3.6)	11	6
Fruits + animals	373	20.7 (5.0)	20	14	20.5 (5.7)	20	12	18.4 (5.8)	18.5	10
Object naming	362	14.7 (0.6)	15	13	14.5 (1.2)	15	13	14.0 (1.2)	14	12
Constructional praxis	357	9.2 (2.8)	10	4	8.5 (3.1)	9	3	7.7 (3.3)	9	2
Word list learning	370	16.3 (3.7)	16	11	15.2 (4.2)	16	9	13.1 (3.6)	13	8
Word list recall	370	5.6 (1.9)	6	3	4.9 (2.1)	5	2	3.7 (2.1)	4	0
Word list recognition										
Originals	370	9.1 (1.4)	10	6	9.2 (1.3)	10	7	9.1 (1.4)	10	7
Foils	370	9.5 (1.1)	10	8	8.8 (2.1)	10	6	7.9 (3.0)	9	1

Note. HMSE = Hindi Mental State Exam.

[a]Sample size is less than 374 for some tests because some subjects did not complete all tests.

TABLE 3. Distribution of Test Scores by Gender and Literacy

	Men, n = 200								Women, n = 174							
	Able to Read and Write				Not Able to Read and Write				Able to Read and Write				Not Able to Read and Write			
Test	n[a]	Mean (*SD*)	Median	10th Percentile	n[a]	Mean (*SD*)	Median	10th Percentile	n[a]	Mean (*SD*)	Median	10th Percentile	n[a]	Mean (*SD*)	Median	10th Percentile
HMSE Total	72	28.6 (1.9)	29	26	128	24.9 (3.9)	26	19	9	26.1 (3.7)	27	18	165	24.4 (4.0)	26	18
HMSE Calculate	72	4.5 (0.9)	5	3	122	3.4 (1.6)	4	0	8	2.8 (2.0)	3	0	144	2.4 (1.6)	2	0
Verbal fluency																
Fruits	72	10.1 (2.4)	10	7	128	7.5 (3.0)	7	3	9	9.3 (4.2)	9	2	165	7.9 (2.4)	8	4
Animals	72	13.9 (3.9)	13.5	9	128	11.1 (3.4)	11	6	9	12.3 (5.9)	12	3	164	11.2 (3.4)	11	6
Fruits + animals	72	24.0 (5.4)	23.5	18	128	18.6 (5.3)	19	11	9	21.7 (9.9)	19	5	164	19.1 (4.6)	19	12
Object naming	72	14.9 (0.3)	15	14	122	14.3 (1.1)	15	13	9	14.4 (1.1)	15	12	159	14.3 (1.2)	15	12
Constructional praxis	72	10.8 (1.7)	11	9	122	8.1 (2.9)	9	3	9	8.1 (4.6)	10	0	154	7.8 (3.2)	8	2
Word list learning	72	17.6 (3.6)	18	12	126	13.4 (4.1)	13	8	9	16.2 (3.6)	17	11	163	14.7 (3.7)	15	9
Word list recall	72	5.9 (2.0)	6	3	126	4.0 (2.3)	4	0	9	5.2 (2.5)	5	2	163	4.8 (1.9)	5	2
Word list recognition Originals	72	9.3 (1.2)	10	7	126	8.9 (1.6)	10	6	9	9.0 (1.8)	10	5	163	9.3 (1.1)	10	7
Word list recognition Foils	72	9.7 (0.8)	10	9	126	8.5 (2.4)	9	5	9	9.3 (1.3)	10	6	163	8.5 (2.6)	10	5

Note. HMSE = Hindi Mental State Exam.
[a]Sample sizes differ because some subjects did not complete all tests.

optimal grading of performance. Norms for the test(s) should be known or established for a given population before the test is used to distinguish potentially "abnormal" (e.g., demented) persons from their "normal" peers (Chandra et al., 1994). Normative scores are also useful for characterizing populations and comparing them with others; however, such comparisons should be made judiciously when different versions of the tests have been used in different populations, as is the case in the Ballabgarh and Monongahela Valley studies.

Effects of Education

The problem of culture is compounded by the issue of education. We (Ganguli et al., 1991) and others (Escobar et al., 1986; Fillenbaum et al., 1988; O'Connor et al., 1989; Salmon et al., 1989) have previously shown that lesser education is associated with lower cognitive test performance in a variety of populations. A growing body of epidemiological literature also suggests that lower levels of education are associated with a higher prevalence of dementia (Mortimer & Graves, 1993; Zhang et al., 1990). Several hypotheses might explain this observed relationship. Lack of education may merely limit scores on the tests that screen for the effects of dementing disorders; it may indicate low premorbid levels of intellectual functioning; it may diminish "brain reserve" leading to earlier manifestation of the effects of dementing disorders (Katzman, 1993); it may serve as a surrogate for other (e.g., economic, nutritional) deprivations causing the actual neuronal loss characteristic of the dementing disorders. Such hypotheses provide powerful incentives for the study of uneducated societies; they also magnify the methodological challenge of developing appropriate cognitive tests for uneducated and illiterate populations (Chandra et al., 1994; Ganguli et al., 1995).

In the MoVIES cohort (Ganguli et al., 1991), as in other populations, low scores on cognitive tests were associated not only with lesser education but also with greater age. The same relationships are apparent in the Ballabgarh cohort, where both age and educational ranges are lower than in the Monongahela Valley. As in the U.S. sample, older Indian subjects in the present study had less education, most likely a cohort effect due to limited educational opportunities in previous times. In addition, women in the Indian sample were much less likely than men to have been educated; it is likely that the lower scores obtained by women were attributable to their lack of education. Graves and colleagues (1994) have noted that educational experience is likely to interact with gender, especially in older age groups and in certain cultures. When variation in level of education is due to variation in opportunity, rather than in ability, interpretation of cognitive scores is rendered even more difficult.

Establishment of Screening Criteria

Although the determination of normative values is important in its own right, our primary purpose in doing so was to establish cognitive screening criteria for a study of dementia epidemiology. In the MoVIES study, we decided against screening with a single conventional cutpoint on the MMSE. Instead, we established population-based, operational screening criteria for cognitive impairment: We required a subject to have scores at or below the 10th percentile of the population on either the MMSE and/or on at least one test of memory and one test of another cognitive domain. These criteria improved sensitivity for dementia, without lowering specificity, over the use of a standard MMSE cutpoint alone (Ganguli et al., 1993). Further, we have shown that adjustment of scores for gender and education within age groups did not improve sensitivity and specificity overall in the MoVIES sample (Belle et al., 1996). In the Ballabgarh study, we are now employing similar criteria to classify subjects as cognitively impaired, using as screening cutpoints the overall 10th percentile scores reported in Table 1. Thus, on the basis of cognitive screening, a subject is classified as impaired and referred for clinical evaluation if he/she scores 19 or less on the HMSE, and/or obtains scores at or below the 10th percentile on a memory test and at least one other test. As previously suggested by White (1989), we recommend that cognitive scales be similarly calibrated in any new population in which they are to be employed for screening. Ongoing screening and diagnostic evaluation of this population will allow us to calculate the actual sensitivity and specificity of these measures for dementia in Ballabgarh, and to compare these rates with those found in the Monongahela Valley. Prospective follow-up of both cohorts will permit us to determine the extent to which changes, over time, in scores in the Hindi test battery are comparable to those seen in the English-language battery in the MoVIES study. Comparisons across studies should taken into account differences in the form and content of the tests as well as demographic differences between study populations.

Conclusions

We have described a battery of cognitive tests that was developed for screening an illiterate elderly rural Hindi-speaking population, and reported scores on these tests from a nondemented sample. Our methods of test development, the tests themselves, and the normative data from our sample should be useful to other investigators engaged in studies of the elderly in developing societies, especially of less educated and illiterate segments of those populations.

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Acknowledgments. The work reported here was supported in part by Grants #AG09202 and #AG07562 from the National Institute on Aging, U.S. Department of Health and Human Services. The authors acknowledge the following individuals whose efforts and support made this work possible: in New Delhi and Ballabgarh, Dr. L. M. Nath, Dr. Arun Mehta, Mr. B. S. Nair, Mr. R. K. Kaushik, Mr. Roshan Lal, Mr. Gajraj Singh, Mr. Desh Raj, and Mr. Vijay Ram; in Pittsburgh, Dr. Christopher Ryan, Dr. Carol Baker, Dr. Steven T. DeKosky, Ms. Deborah Echement, Ms. Janet Johnston, and Ms. Catherine Moran. We are also grateful for the cooperation extended by Dr. Suresh Kapoor, Mr. Guresh Kumar, and other staff of the Comprehensive Rural Health Services Project (Centre for Community Medicine, All-India Institute of Medical Sciences, New Delhi) for giving us access to their Ballabgarh facilities and census database.

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