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The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS): Preliminary Clinical Validity*

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ABSTRACT

Neuropsychological assessment of older individuals with dementing illnesses has suffered from a lack of appropriately designed test instruments. The Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was developed for the dual purposes of identifying and characterizing abnormal cognitive decline in the older adult and as a neuropsychological screening battery for younger patients. The entire battery takes less than 30 minutes to administer, and yields scaled scores for five cognitive domains. The current study reports preliminary clinical validity results with the RBANS, comparing very mildly demented patients with a diagnosis of probable Alzheimer's disease (n = 20) to patients with Huntington's disease (n = 20) and normal controls (n = 40). Although the patient groups had essentially identical total scores on the RBANS, they exhibited opposite profiles, differing significantly on four of the five subsections. The AD patients performed most poorly on Language, and Delayed Memory subsections, while the HD patients obtained their lowest scaled scores on the Attention and the Visuospatial/Constructional subsections. These results are consistent with the neuropsychological profiles of these dementing disorders derived from lengthier standardized tests and experimental investigations. In addition, even those patients who performed above the suggested cut-off points on the MMSE and the Dementia Rating Scale scored significantly below their controls on the RBANS. These data suggest that the RBANS is effective at both detecting and characterizing dementia of different etiologies.

The neuropsychological assessment of older patients with known or suspected dementia has suffered from a lack of appropriately designed test instruments (cf., Randolph, Mohr, & Chase, 1993). Most current standardized neuropsychological tests are designed to avoid ceiling effects in young normals, and are excessively difficult for this population. Older individuals may also be more prone to fatigue and less likely to endure a lengthy neuropsychological evaluation, which typically exceeds 6 hours (Putnam & DeLuca, 1990). The difficulty level, length, and lack of alternative forms of existing standardized neuropsychological tests also limits their utility in tracking disease progression or monitoring outcome in clinical trials of antidementia medications.

On the other hand, existing dementia/mental status screening tests, such as the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) or the Dementia Rating Scale (DRS; Mattis, 1976) are relatively insensitive to mild dementia (e.g., Petersen, Smith, Ivnik, Kokmen, & Tangalos, 1994). They also do not allow for clinically useful profiling of abilities across cognitive domains (Feher et al., 1992), which is of potential utility in differential diagnosis and treatment planning. In part, this may

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be due to the fact that until relatively recently, little was known about the nature of early cognitive deficits in dementing illnesses or how these early deficits differed across dementias of various etiologies.

Recent studies have established the utility of certain types of neuropsychological tests in the early detection of dementia. The use of a verbal serial list learning task has been shown to be a particularly sensitive measure of early dementia (Flicker, Ferris, & Reisberg, 1991; Masur, Sliwinski, Lipton, Blau, & Crystal, 1994; Peterson et al., 1994). Immediate recall of stories (Eslinger, Damasio, Benton, & Van Allen, 1985; O'Donnell, Drachman, Let, & Swearer, 1988), a timed coding task such as Digit Symbol from the WAIS-R (Masur et al., 1994; Newman, Warrington, Kennedy, & Rosser, 1994), and semantic fluency tests (Masur et al.) have also been identified as sensitive to cognitive deficits associated with very early Alzheimer's disease (AD).

A number of studies have also suggested that dementias of differing etiologies may have distinct neuropsychological profiles. The most common distinction made is between ''cortical'' dementias (usually AD) and ''subcortical'' dementias produced by diseases involving a greater degree of pathology in subcortical nuclei or white matter, such as Huntington's disease (HD), Parkinson's disease (PD), vascular dementia, and progressive supranuclear palsy (cf. Brown & Marsden, 1988). The majority of this work has been done in the context of basic research into brain-behavior relationships within specific domains of cognition such as memory (e.g., Heindel, Salmon, & Butters, 1989; Pillon, Deweer, Agid, Dubois, 1993; Randolph, 1991) or language (e.g., Monsch et al., 1994; Randolph, Braun, Goldberg, & Chase, 1993).

Typically, such studies report poor immediate memory and/or blunted learning curves in all groups, with the worst performance by AD patients. Patients with subcortical dementias are typically found to display better retention over time, perform better on recognition testing, and exhibit fewer errors of intrusion than AD patients (Butters, Granholm, Salmon, Grant, & Wolfe, 1987; Delis et al., 1991; Hodges, Salmon, & Butters, 1990). Patients with AD typically are also reported to perform more poorly on confrontation naming tests and semantically controlled verbal fluency tasks, whereas patients with HD have been reported to perform more poorly than AD patients on phonemically controlled (letter) fluency tasks (Monsch et al., 1994; Randolph, Braun, et al., 1993). In contrast, patients with various forms of ''subcortical'' dementia are often described as more impaired on tests of attentional function or cognitive processing speed.

Using the Wechsler Memory Scale-Revised (WMS-R; Wechsler, 1987), Tröster and colleagues computed difference scores between the General Memory Index and the Attention/Concentration Index, and compared HD patients to AD patients. They found that AD patients demonstrated a significant relative preservation of attentional functions in comparison to HD patients (Tröster, Jacobs, Butters, Cullum, & Salmon, 1989; see also Butters et al., 1988). Brandt, Folstein, and Folstein (1988) also reported that HD patients were significantly worse than AD patients in subtracting serial sevens, a task usually considered attentional in nature. In comparing AD and HD patients on the DRS, Salmon et al. reported that HD patients were significantly worse than AD patients on the Initiation section, with a trend to perform worse on the Attention section (Salmon, Kwo-on-Yuen, Heindel, Butters, & Thal, 1989).

In summary, the majority of studies to date that have compared dementias of differing etiologies on neuropsychological tests have employed largely experimental tests in an attempt to explore brain-behavior relationships across only a limited number of cognitive domains. There is sufficient evidence, however, to suggest that there are some qualitative differences in the profile of cognitive impairment among these disorders, particularly between patients with AD and patients with HD.

Unfortunately, the currently available instruments for the assessment of dementia all have significant shortcomings in terms of the translation of these empirical findings into *clinically useful* application. These shortcomings include the excessive length and difficulty (for many

patients) of tests such as the WMS-R, the general insensitivity of screening tests such as the MMSE or the DRS, and the lack of referential scaling or population-based normative data for the DRS or tests such as the CERAD battery (Morris, Heyman, & Mohs, 1989), which is a well-designed brief dementia battery used by many of the University-based Alzheimer's disease centers around the US. Another relatively recently constructed test, the Alzheimer's Disease Assessment Scale (Rosen, Mohs, & Davis, 1984), has enjoyed widespread use as an outcome measure in clinical trials of experimental therapeutics for Alzheimer's disease. Unfortunately, this scale has been reported to be insensitive to early dementia (Zec et al., 1994) and lacks both population-based normative data and referential scaling. It was also constructed largely as a subjective rating scale, rather than a psychometric instrument.

One of the primary design goals for the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) was for the specific purpose of identifying and characterizing dementia in older individuals. As a result, the following design goals were met:

(1) ***Overall length of battery to be less than 30 minutes***. This was felt to be important in maximizing patient cooperation and minimizing effects of fatigue on performance.

(2) ***Level of difficulty appropriate for range from normal older adult through moderately severe dementia***. Existing standardized neuropsychological tests are excessively difficult for this population, while dementia screens are insensitive to mild impairment. The RBANS was designed to bridge this gap.

(*3*) ***Measurement of cognitive functions typically affected by dementing disorders, with production of scaled score profiles***. In addition to incorporating measures which are known to be sensitive to dementia, the ability to **profile** impairment across cognitive domains was felt to be critical in characterization of the dementia, which may be important in terms of differential diagnosis and treatment planning.

(*4*) ***Availability of alternate forms for evaluation of disease progression or outcome testing of therapeutics***. The battery was designed to be amenable to the construction of multiple equivalent forms. This is important in avoiding practice effects in the measurement of disease progression or in screening for symptomatic improvements in response to therapeutic interventions.

The RBANS underwent a US nationwide, population-based standardization with adults aged 20–89 years. It is scheduled for publication in 1998. The present study reports on preliminary clinical validity results of a study of 80 subjects: Twenty patients with mild AD, 20 patients with mild HD, and 40 age- and education-matched controls. Our hypothesis was that the RBANS would prove sensitive in terms of detecting dementia in both patient groups, and would also be able to identify distinct profiles of impairment that would distinguish the patient groups from each other. Such findings would support the clinical utility of this battery in the neuropsychological assessment of dementing illnesses.

METHOD

Participants

A total of 80 persons participated in this study. Twenty of these were patients with a diagnosis of probable AD according to the criteria of the National Institute of Neurological Disorders and Stroke and the Alzheimer's Disease and Related Diseases Association (NINCDS-ADRDA; McKhann et al., 1984). Routine laboratory tests for the differential diagnosis of dementia, including magnetic resonance imaging scans, were carried out on all AD patients. All patients also had complete physical, neurological, and neuropsychological examinations. None of these patients were taking medications that affected the central nervous system.

Twenty patients with a diagnosis of HD also participated in the study. These patients were diagnosed on the basis of a positive family history and the presence of choreiform movements. Disease severity ranged from 6 to 12 on Shoulson's (1981) scale. None of the HD patients were medicated at the time of the study.

Normal controls were recruited by advertisement and were paid for their participation. They were matched to the patients on the basis of age and years of education, and as a result neither pa-

tient group differed significantly from their control group on these variables. One group of 20 older normal controls (ONC) was matched to the AD patients; a second group of 20 younger normal controls (YNC) was matched to the HD patients. None of the normal controls had any history of neurological or psychiatric disease and none were taking any medications that affected the central nervous system at the time of testing.

The demographic characteristics of the subject groups are listed in Table 1. Sixty percent (12/20) of the AD group had a MMSE score above the commonly used cut-off score of 23; 60% (12/20) of the HD patients also had MMSE scores above 23. Not all patients received the DRS. Of those that did, 36% (5/14) of the AD patients scored above the suggested cut-off score of 123 (Mattis, 1988) and 58% (7/12) of the HD patients scored above 123. There was no significant difference in MMSE scores between patients who did and did not receive the DRS. The mean MMSE of the AD patients who received the DRS was 22.8; the mean MMSE of those AD patients who did not was 23.7. The mean MMSE score of the HD patients who received the DRS was 23.9; the mean MMSE of those who did not was 24.6.

Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)

The RBANS consists of five indexes (see below). Stimuli are contained in a wire-bound, easel-type booklet, making the test easily portable and allowing for bedside administration. Total administration time is 20-30 mins. Two alternate forms are scheduled for publication. All subjects in this study received form A. The battery indexes are:

(1) Immediate Memory

This index consists of the following two subtests: **(a) List Learning** consists of immediate recall of a 10-item list of words over four learning trials. The words are semantically unrelated, early age-of-acquisition, relatively high-imagery, and as phonetically unique as possible. (b) **Story Memory** consists of a 12-item story, read aloud for immediate recall over two trials. Recall is scored using a verbatim criterion, in order to avoid complicated scoring rules.

(2) Visuospatial/Constructional

This index consists of the following two subtests: **(a) Figure Copy** consists of copying a geometric figure comprised of 10 parts. Each part receives a 2-point score (accuracy and placement), for a total of 20 possible points. (**b) Line Orientation** consists of a 10-item line orientation test. Each item involves a radiating array of 13 lines spanning 180 degrees; below the array are two target lines that are identical in orientation to two of the lines from the array. The subject's task on each item is to identify the matching lines. One point is given for each correctly matched line, for a total score of 20.

(3) Language

This index consists of the following two subtests: (**a) Picture Naming** consists of 10 line drawings, which the subject must name. Semantic cues are given if the object is obviously misperceived (e.g., ''umbrella'' for mushroom). **(b) Semantic Fluency** consists of the total number of exemplars generated for a given semantic category (e.g., fruits and vegetables) within 60 seconds. The semantic categories used were chosen in order to attempt to minimize retrieval demands and thereby more specifically tap semantic stores rather than retrieval strategies (cf. Randolph, Braun, et al., 1993).

(4) Attention

This index consists of the following two subtests:

Table 1. Subject Characteristics .

Group	*n*	Gender (M/F)	Age (years)		Educ. (years)		MMSE		DRS	
			M	(*SD*)	*M*	(*SD*)	*M*	(*SD*)	*M*	(*SD*)
AD	20	8/12	66.7	(5.5)	13.2	(3.4)	23.5	(3.4)	121.3	(7.5)[a]
ON C	20	10/10	68.3	(6.1)	13.8	(2.7)				
HD	20	10/10	47.6	(12.6)	12.2	(3.3)	24.3	(3.5)	120.8	(19.6)[b]
YNC	20	10/10	47.2	(9.2)	13.5	(2.8)				

Note. AD = Alzheimer's disease; ONC = old normal controls; HD = Huntington's disease; YNC = young normal controls; SD = standard deviation; MMSE = Mini-Mental State Examination; DRS = Dementia Rating Scale.
[a] N = 14.
[b] *n* = 12.

(a) Digit Span is analogous to digits forward on the WAIS (Wechsler, 1955). There are two string of digits in each item, at lengths increasing from 2 to 9 digits. The second string at a given length is only read if the first string is failed. **(b) Coding** is similar in nature to the Symbol Digit Modalities Test (Smith, 1973) or the Digit Symbol subtest of the WAIS-R. Numbers rather than symbols were chosen for the response in order to avoid the possible detrimental effect of a constructional apraxia on performance. The score is the total number of items completed in 90 seconds.

(5) Delayed Memory

This index includes four subtests: (a) List Recall involves free recall of the words from the List Learning task. **(b) List Recognition** involves yes/no recognition testing for memory of the words from the List Learning task. **(c) Story Recall** involves free recall of the story from the story memory test. **(d) Figure Recall** involves free recall of the figure from the figure copy subtest.

SCALING: In the production version of this test, each index score will be separately scaled by age group to a scaled score mean of 100 with associated *SD* of 15. This will allow for a profile of performance across cognitive domains, and a total scaled score will be derived from the the sum of these, also with a normal mean of 100 and standard deviation of 15.

For the purpose of the present study, a single reference sample was used to provide these scaling metrics. This was a separate group of 50 normal individuals ranging in age from 40 to 89 years (mean = 66), with an average education level of 11.8 years. Raw scores were converted into scaled scores for all subjects in the present study using the same scaling metric, regardless of age. The reason for scaling the raw scores in the present study was for the purpose of presenting profiles as they will appear when the scale is published. All statistical results reported below for the scaled scores also obtain for raw score totals.

RESULTS

Scaled Scores

The distribution of raw scores in each patient group and the normal controls for each of the five indexes met assumptions of normality prior to (and following) scaling conversion (Univariate Procedure, SAS System). The scaled scores for the five indexes were analyzed by MANOVA for the four groups, followed by post hoc *t*-test comparisons among groups. The overall MANOVA was significant ($F = 14.2$, $p < .0001$). Post hoc *t*-tests results are summarized in Table 2 and the means for each group across indexes are graphically depicted in Figure 1. Although the YNC group outperformed the ONC group across indexes, the only comparison that reached statistical significance was on the Immediate Memory Subsection. Both control groups performed numerically above the reference sample means of 100; this is likely due to higher education levels of subjects in the present study in comparison to the reference sample. The HD patients differed from both control groups on all indexes. The AD group differed from the controls on all indexes except Visuospatial/Constructional. The difference between AD and HD patients was significant on all indexes except for Immediate Recall. The total scaled score was nearly identical for the two patient groups (AD = 81.4; HD = 81.5), indicating comparable overall levels of dementia.

Table 2. Results of *T*-Test Comparisons of Groups by Subsections.

Immediate Memory	Visuospatial/ Constructional	Language	Attention	Delayed Memory
A YNC	**A** YNC	**A** YNC	**A** YNC	**A** YNC
B ONC	**A** ONC	**A** ONC	**A** ONC	**A** ONC
C HD	**A** AD	**B** HD	**B** AD	**B** HD
C AD	**B** HD	**C** AD	**C** HD	**C** AD

Note. Groups with different prefix letters had Index score means significantly different at the $p < .05$ level for that subsection. AD = Alzheimer's disease; ONC = old normal controls; HD = Huntington's disease; YNC = young normal controls. See Figure 1 for graphical presentation of means.

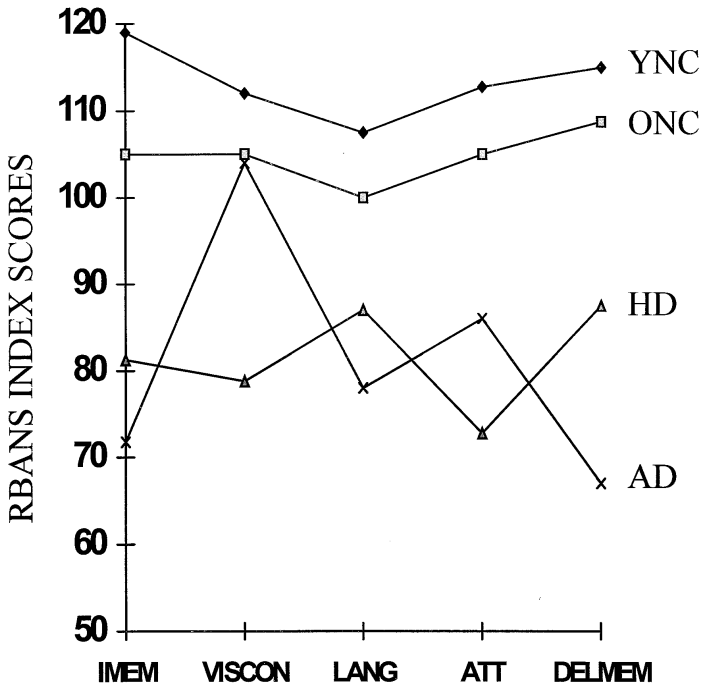

Fig. 1. Index score profiles across RBANS indexes for all four groups in the study. See text for results of statistical analyses. Abbreviations: YNC-young normal controls; ONC-old normal controls; HD-Huntington's disease; AD-Alzheimer's disease; IMEM-Immediate Memory; VISCON-Visuospatial/Constructional; LANG-Language; ATT-Attention; DELMEM-Delayed Memory.

Cortical/Subcortical Profiles

The opposite pattern of performance exhibited by the AD and HD patients suggests that these scaled scores might be used to generate a single discrepancy score that would be useful in distinguishing between patterns of dementia. In order to generate a single score, the mean of the scaled scores of the Delayed Memory and Language indexes was subtracted from the mean of the scaled scores of the Attention and Visuospatial/Constructional indexes. These were the four indexes on which the two patient groups were significantly different. The results are depicted in Figure 2. The two normal control groups did not significantly differ on this measure. Both control groups were significantly different from both patient groups (F values ranged from 10.6 to 23.2, all ps < .002). The HD and AD groups were obviously significantly different on this measure (F[1,38] = 53.4, p < .0001), and there was very little overlap of the patient groups. Setting the cutoff point at 0 and below for a ''subcortical'' score, and above 0 for a ''cortical'' score resulted in an overall overall correct classification rate of 93% (See Table 3).

Patient Group Differences in Memory Performance

Several previous studies have suggested that AD and HD patients display different patterns of performance on memory testing, with HD patients displaying relatively preserved recognition memory performance. This pattern was also observed in the present study.

The two patient groups did not differ on either the total immediate recall for trials 1-4 total of the List Learning subtest (F[1,38] = 1.4, NS), or immediate recall on the Story Memory subtest (F[1,38] = 1.7, NS). They were, however, significantly different on the List Learning De-

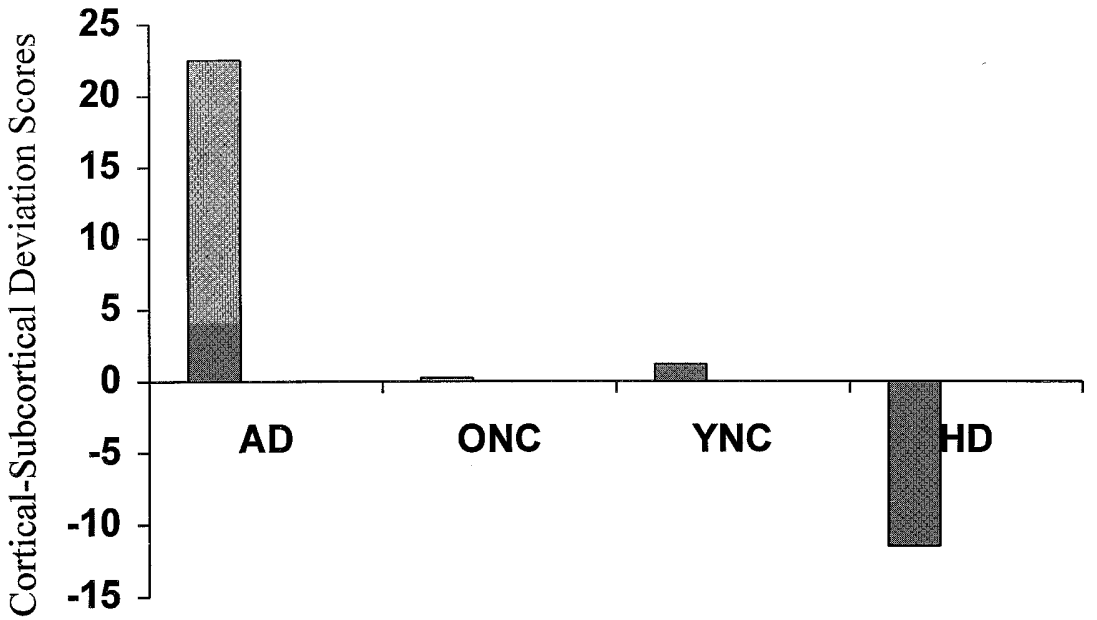

Fig. 2. Group means on the Cortical/Subcortical measure, derived by subtracting the mean of the Language and Delayed Memory Indexes from the mean of the Attention and Visuospatial/Constructional Indexes for each subject. See text for statistical results. Abbreviations: YNC-young normal controls; ONC-old normal controls; HD-Huntington's disease; AD-Alzheimer's disease.

layed Recall (F[1,38] = 17.7, $p < .0002$), on List Learning Recognition (F[1,38] = 8.0, $p < .008$), and on Story Memory Delayed Rcall (F[1,38] = 8.4, $p < .006$). The AD patients performed more poorly than the HD patients on all the delayed memory measures.

RBANS Test Sensitivity

There was very little overlap between the patients and their controls in terms of total scale score. Only 2 subjects from the older normal control (ONC) group had total scores that fell within the range of AD scores, and only 3 subjects from the younger normal control (YNC) group had total scores overlapping the HD range of scores (94% of all subjects in non overlapping distributions). Using a median split for the distributions of total scores for younger (HD, YNC) and older (AD, ONC) groups separately, and classifying the upper 50% of scores as normal and the lower 50% of scores as demented yielded a classification sensitivity of 90% and specificity of 90% as well (36/40 normals and 36/40 patients correctly classified).

As an index of test sensitivity in comparison to the MMSE and the DRS, the RBANS perfor-

Table 3. Classification by ''Cortical/Subcortical Deviation Score''.

Patient Group	Classified as ''Subcortical''	Classified as ''Cortical''
HD Patients	18	2
AD Patients	1	19

Note. AD = Alzheimer's disease; HD = Huntington's disease.

mance of those patients who performed above suggested cut-offs for both the MMSE and DRS was compared to their controls. This was done as per the group comparisons reported above, with a repeated-measures ANOVA on the scaled scores of the five RBANS subtests.

There were 12 AD patients who scored above 23 on the MMSE; the overall group difference between these patients and the ONC group was significant (F[1,30] = 39.6, $p < .0001$). Significant index and index by group interactions were also obtained. These very mildly demented AD patients differed from the older normal controls on every subtest but Visuospatial/Constructional. For purpose of overall comparison, the mean sum of their scaled scores was 82.3, as compared to the ONC mean of 105.9 (SD = 8.9)

Only 14 AD patients received the DRS; of these, 5 obtained scores above 123. Even with this limited power, the difference between these 5 patients and the ONC group was significant (F[1,23] = 15.3, $p < .0008$). Again, there were significant index and index by group interaction terms. These 5 AD patients performed significantly worse than did the ONC group on all indexes but Attention and Visuospatial/Constructional. The mean sum of the scaled scores for these 5 AD patients was 89.2.

There were 12 HD patients with MMSE scores above 23; the overall group difference between these patients and the YNC group was significant (F[1,30] = 45.9. $p < .0001$). Significant index and index by group interactions were also obtained, although the HD group performed significantly worse than did the YNC group on all indexes. For overall comparison, the mean sum of the scaled scores of the HD group was 84.9, as compared to the YNC mean of 113.5 (SD = 8.5).

Only 12 HD patients received the DRS; of these 7 obtained scores above 123. Even with this limited power, the difference between these 7 patients and the YNC group was significant (F[1,25] = 18.5, $p < .0002$). Again, there was a significant overall effect of index and a marginally significant ($p < .054$) index by group interaction term. These 7 HD patients performed significantly worse than did the YNC group on every subtest. The mean sum of the scaled scores for these 7 HD patients was 97.6 (YNC group mean = 113.5, SD = 8.5).

DISCUSSION

This preliminary clinical validity study of the RBANS suggests that it is sensitive both in terms of detecting and characterizing dementia. These two groups of very mildly demented patients both performed well below their age- and education-matched control groups, and displayed markedly different patterns of performance across subtests. This was true even for those patients who performed above the standard cut-offs for the MMSE and the DRS. The pattern of impairments exhibited by each of these groups is consistent with what has been reported previously in studies using a variety of lengthier standardized tests and experimental paradigms.

The AD patients, as expected, performed most poorly on the Delayed Memory Index, which includes measures of free recall and recognition. They were also significantly worse than the HD patients on the Language Index. In contrast, the AD patients significantly outperformed the HD patients on the Attention and Visuospatial/Constructional Indexes. The two patient groups did not differ on the Immediate Memory Index.

Obviously, AD and HD are clinically distinct dementing disorders with virtually no diagnostic overlap. As such, however, they are appropriate for preliminary clinical validity studies such as this, and provide the groundwork for further investigations of disorders which pose more difficult differential diagnostic questions. The fact that the RBANS was able to effectively characterize the dementias associated with these two disorders suggests that it may be useful in the clinical assessment of disorders with a greater degree of clinical overlap. Additional clinical validity studies will include comparison of patients with Alzheimer's disease to patients with vascular dementia, as well as investigations involving a variety of other dementing disorders and depressive disorders in the elderly.

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