

# Computer-Automated Assessment of Dementia Severity Using a Touch-Tone Telephone

James C. Mundt, PhD

Healthcare Technology Systems, Inc.

7617 Mineral Point Road Madison, WI 53717



## ABSTRACT

**Objective:** To evaluate the feasibility of using computer-automated neuropsychological tasks implemented using interactive voice response (IVR) technology to assess performance abilities of elderly subject groups with known differences in dementia severity based on clinician evaluation.

**Methods:** 155 subjects, 56 to 93 years old, were assessed clinically. Each subject was administered a Mini-Mental State Examination (MMSE) and scored with respect to the Clinical Dementia Rating (CDR) scale. CDR scores were used to define four groups of subjects (N = 74, 27, 42, and 12) representing Normal Cognition, Mild Impairment, Mild and Moderate dementia, respectively. These subjects performed a battery of eight computerized tasks administered by an IVR system using standard touch-tone telephones. The battery of tasks included temporal orientation, alphanumeric translation, immediate learning, delayed recall, directed keypressing, auditory spatial relations, backward digit span, and semantic comprehension.

**Results:** Mean call length was 12 minutes 17 seconds  $\pm$  3:17 (SD). Correlations between task performances and CDR scores ranged from -.11 to -.62, and from .12 to .69 with MMSE scores. The correlations between the CDR and MMSE scores are statistically significant ( $p < .05$ ) from all but one task (delayed recall due to floor effects). Analyses of variance of IVR task performance scores using CDR scores as a between-subjects grouping variable indicated significant ( $p < .05$ ) group differences in 7 of the 8 tasks. Linear contrasts across subject groups account for over 95% of the between-group variance.

**Conclusions:** Measuring change in cognitive functioning over time requires monitoring mechanisms. Removing barriers to such mechanisms, such as making them available via standard touch-tone interfaces, may provide wider research opportunities than have previously been available.

## IVR Test Modules

**Subjective Memory Complaint.** Subjects reported any difficulty remembering names of family or friends, finding words or objects, or use of notes to avoid forgetting.

**Orientation.** Subjects were asked to enter the current: (a) year; (b) season; (c) month; (d) day of the month; and (e) day of week.

**Alphabetic translation.** The subjects were asked to spell the word "FUN" (3,8,6) and given the context "as in "The party was fun." to assure comprehension.

**Immediate recall.** Subjects heard the digit sequence "2 7 6 0 4" and were asked to enter these digits in the same order. The procedure was repeated three times.

**Directed keypressing.** Subjects were directed to press particular keys a specific number of times (e.g., "Press the '7' key three times." "Press six times on the '3' key."). Performance continued until 30 seconds had elapsed since task initiation.

**Delayed recall.** Subjects were asked to recall the 5-digit sequence of the immediate recall trials.

**Auditory spatial relations.** Subjects heard an auditory description of key locations (1-9) according to the standard 3 X 3 matrix on most telephones (1-3 top row, 4-6 middle row, and 7-9 third row), and asked to press the identified key. "TOP-LEFT" key corresponds to the '1' key; "RIGHT-BOTTOM" key would be the '9'. Total task duration was 30 seconds.

**Backward digit span.** Subjects heard four-digit number sequences on three successive trials and were asked to press the identified keys in reverse order.

**Semantic comprehension.** Subjects heard six declarative statements and were asked to judge whether or not each statement made sense. Three statements made sense (e.g., "The woman burned herself badly when she spilled a pot of hot soup on herself while preparing dinner."), and three did not (e.g., "We wanted to cut down a tree in our front yard, so we went to the garage to get our hammers.").

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## SUBJECTS

One hundred fifty five subjects were recruited from a geriatrics practice (Dean Medical Center; N = 91) and neurology research at the University of Iowa (N = 64). Study participants were not compensated.

<b>AGE:</b>	56 to 93 years old.	(Mean = 76.7; SD = 7.0 years)
<b>EDUCATION:</b>	6 to 22 years	(Mean = 13.3; SD = 3.0 years)
	< HS diploma or GED:	13.5%
	HS diploma or GED:	51.0%
	2 or 4 year degree:	22.6%
	Graduate degree:	12.9%
<b>GENDER:</b>	98 women, 57 men	
<b>MARITAL STATUS:</b>	Married:	61.3%
	Widowed:	31.0%
	Divorced:	5.2%
	Never married:	2.6%

Subjects were given a Mini-Mental State Exam (MMSE) and clinicians provided ratings for Clinical Dementia Rating (CDR) scale. The CDR obtains an impairment rating for each of six functional areas: memory, orientation, judgment and problem solving, community affairs, home and hobbies, and personal care. CDR scores were used to stage dementia levels.

<b>CDR Score</b>	<b>Dementia Stage</b>	<b>N</b>
0	no cognitive impairment	74
0.5	uncertain or deferred diagnosis	27
1	mild stage dementia	24
2	moderate stage dementia.	12
3-5	severe, profound, terminal	--

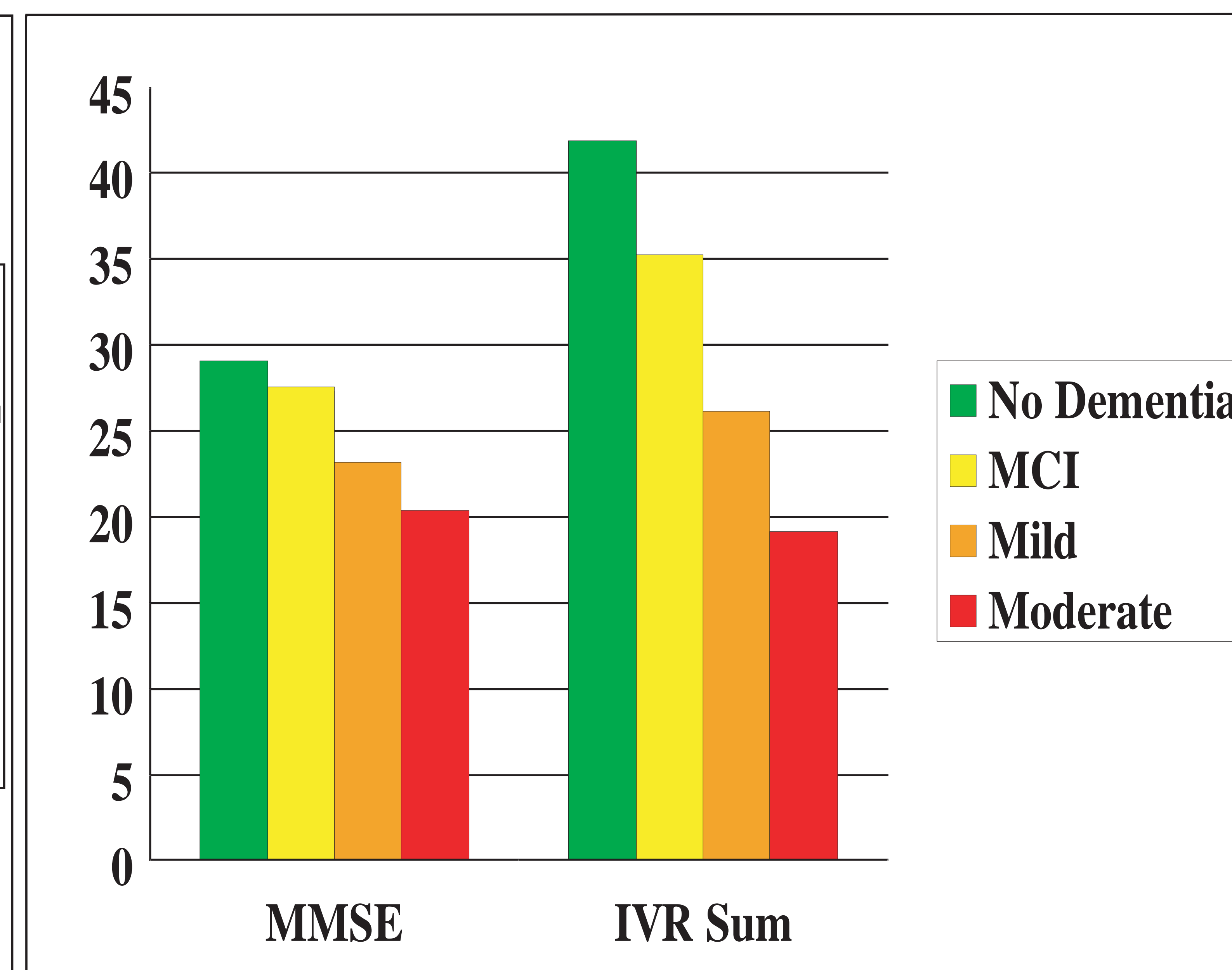
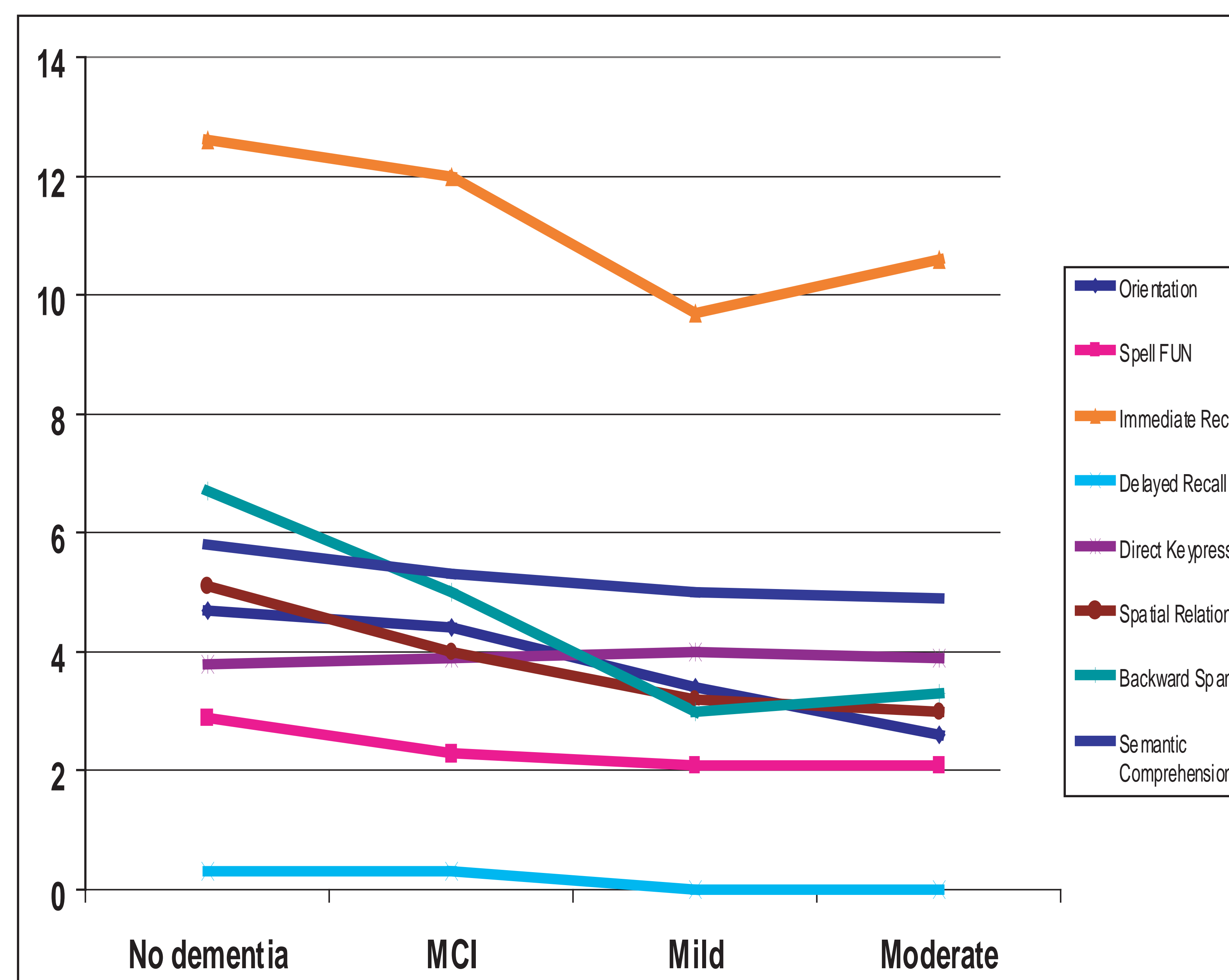
## Task Performance Correlations with Dementia Severity

TASK	CDR	MMSE
Orientation	-.62**	.69**
Alphabetic Translation	-.41**	.47**
Immediate Recall	-.36**	.46**
Directed Keypressing	-.16	.25**
Delayed Recall	-.11	.12
Auditory Spatial Relations	-.41**	.43**
Backward Digit Span	-.41**	.53**
Semantic Comprehension	-.42**	.53**
Sum of IVR Tasks	-.62**	.70**

\*\*  $p < .01$

## CONCLUSION

Valid assessment of cognitive functioning can be obtained using interactive voice response technology. Such assessments made available via touch-tone telephones provides wider research and clinical opportunities for longitudinal monitoring than has previously been available.



Analysis of task performances using CDR scores as a between-subjects factor were significant ( $p < .05$ ) for all tasks except Delayed Recall (floor effect) and Directed Keypressing (ceiling effect).

$F(3,151) = 113.01, p < .001$  Differences between each group significant ( $p < .05$ ), Student-Newman-Keuls contrasts.  
 $F(3,151) = 32.24, p < .001$  Differences between each group significant ( $p < .05$ ), Student-Newman-Keuls contrasts.