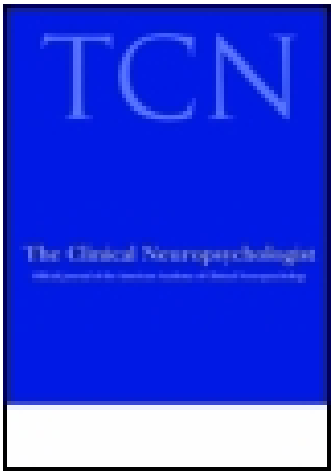

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Diagnostic accuracy of the Phototest for cognitive impairment and dementia in Argentina

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Phototest is a simple, easy and very brief test with theoretical advantages over available dementia screening tests in Spain. The objective of this study was to estimate the diagnostic accuracy of the Phototest for cognitive impairment and dementia and to compare it with that of the MMSE and the Clock Drawing Test (CDT) in an Argentine population. A phase II cross-sectional study of diagnostic tests evaluation was performed in a sample of 30 controls, 61 with amnestic mild cognitive impairment (a-MCI), and 56 with mild Alzheimer type dementia (DAT). The diagnostic accuracy (DA) was assessed in relation to the clinical diagnosis by calculating the area under the ROC curve (UAC), Sensitivity (Sn), and Specificity (Sp).The DA of the Phototest for a-MCI and DAT (0.93 and 0.97 [UAC]) was higher than that of the MMSE and the CDT. The cut-off points of 27/28 for DAT (Sn = 89.29 [78.1–96.0], Sp = 96.67 [82.8–99.9]) and 30/31 for a-MCI (Sn = 85.25 [73.8–93.0], Sp = 90.00 [73.5–97.9]) maximized the sum of Sn and Sp. Phototest correlates significantly with MMSE and CDT. The Phototest is an efficient instrument for the detection of mild dementia or MCI, with good accuracy and good correlation with tests measuring overall cognitive impairment.

Keywords: Accuracy; Alzheimer's disease; Mild cognitive impairment; Screening.

INTRODUCTION

The detection and early diagnosis of dementia are becoming increasingly important as our population ages. Identifying dementia early in its course is critical for a number of reasons. Having a formal diagnosis helps to explain symptoms and cognitive problems that were distressing because the cause was unknown (Bass, McClendon, Deimling, & Mukherjee, 1994; Carpenter et al., 2008). It also enables patients to plan for their future before cognitive decline begins to interfere with their judgment and reasoning. An early diagnosis offers caregivers the opportunity to advance the process of adaptation to the caregiver role. There is convincing evidence that multicomponent caregiver interventions in the mild to moderate dementia stages are effective to improve caregiver well-being and delay institutionalization (de Vugt & Verhey, 2013). Finally, early identification may be clinical and cost effective (Banerjee & Wittenberg, 2009)

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and may result in cost savings and health benefits compared with no treatment or treatment in the absence of early assessment (Getsios, Blume, Ishak, Maclaine, & Hernández, 2012). On the other hand, the costs of dementia to society extend beyond these direct costs, as the disease impacts individuals, families, and caregivers both economically and in terms of their quality of life (Castro, Dillon, Machnicki, & Allegri, 2010).

Although the reasons for early identification of dementia are compelling, research has shown that primary care physicians fail to diagnose mild to moderate dementia at least 50% of the time (Cooper, Bickel, & Schäufele, 1996; Valcour, Masaki, Curb, & Blanchette, 2000). Numerous works have examined the knowledge physicians have of dementia (Pucci et al., 2004) and the reasons for the absence of early diagnosis in general practice (Cahill et al., 2008). As a matter of fact, some reasons identified to explain this under diagnosis are the lack of simple tests, difficulties in disclosing the diagnosis, difficulties in managing behavioral symptoms, and lack of time. Overall, it seems important to regard improvement in diagnostic practices. The first step should be to detect and identify symptoms of dementia (Villars et al., 2010). However, there is currently no evidence to support screening for cognitive impairment or dementia in asymptomatic people. Most clinical practice guidelines recommend maintaining an alert attitude and using screening tests in suspected cases for the early identification of these patients in primary care (Boustani, Peterson, Hanson, Harris, & Lohr, 2003; Petersen et al., 2001).

Short cognitive tests are considered more appropriate screening instruments than long tests for cognitive impairment in the clinical setting (Carnero Pardo, 2002). There are validated Rioplatense-Spanish version of dementia screening instruments in Argentina as the Mini Mental State Examination (MMSE; Allegri et al., 1999; Butman et al., 2001; Folstein, Folstein, & McHugh, 1975); the Addenbrooke's Cognitive Examination (ACE; Sarasola, Calcagno, Sabe, Caballero, & Manes, 2004), the Addenbrooke's Cognitive Examination Revised (ACE-R; Torralva et al., 2011), the Memory Impairment Screen (MIS; Rojas, Serrano, & Allegri, 2008) the shortened form of the Spanish Boston Naming Test (Serrano et al., 2001), the Spanish Verbal Fluency (Butman, Allegri, Harris, & Drake, 2000) and the Clock Drawing Test (CDT; Gigena, Mangone, Baumann, DePascale, & Sanguinetti, 1993). These screening tests are the most commonly used instrument by general practitioners, but show education and language/cultural bias (MMSE, ACE, MIS, Spanish Verbal Fluency, CDT), are described as impractical because they take 10–20 minutes to administer (MMSE, ACE, ACE-R), require paper and pencil (MMSE, ACE, ACE-R, CDT), only evaluate memory (MIS) and cannot be applied to illiterate persons (MMSE, ACE, ACE-R, MIS).

Phototest (http://www.fototest.es) is a brief screening test of easy application suitable for primary care centers, uninfluenced by educational variables, valid and accurate to identify cognitive impairment or dementia in routine clinical practice (Carnero Pardo et al., 2007; Carnero-Pardo, & Montoro-Rios, 2004), and more effective and less costly than MMSE (Carnero-Pardo, Sáez-Zea, Montiel-Navarro, Feria-Vilar, & Gurpegui, 2011). The objective of this study was to estimate the diagnostic accuracy of the Phototest for cognitive impairment and dementia and to compare with other screening tests in an Argentine population (see Supplemental Material).

METHOD

Design

This was a phase II cross-sectional study of elderly clinical patients attending the cognitive neurology department of the Hospital Mario V. Larrain, Berisso and Hospital Dr, Abel Zubizarreta, Buenos Aires, Argentina, selected by convenience sampling of consecutive patients suspected of cognitive impairment between January and March 2007.

Participants

A total of 147 people participated and were placed in one of three groups: a mild Alzheimer type dementia (DAT) (n = 56), an amnestic mild cognitive impairment (a-MCI) group (n = 61), and a control group (n = 30). All patients were evaluated and recruited by experienced behavioral neurologists (MJR, LB, and RFA).

The initial clinical diagnosis of both a-MCI and DAT was consistent with the results of a detailed 30-minute semi-structured clinical interview of patients and families, serum studies, and structural imaging studies such as MRI or CT. Final diagnosis was agreed on by neurologists, psychiatrists, and neuropsychologists during memory clinic consensus conferences. The Phototest was not used for the initial diagnosis of research participants.

DAT diagnosis was based on history of gradual onset and progressive cognitive impairment relative to premorbid memory abilities, and on at least one of five other areas examined, namely: judgment and problem-solving, orientation, home and hobbies, community affairs, and personal care. Probable DAT diagnosis was based on National Institute of Neurological and Communicative Disorders and Stroke (NINCDS) and Alzheimer's Disease and Related Disorders Association (ADRDA) criteria (McKhann et al., 1984), as well as on Diagnostic and Statistical Manual of Mental Disorders–Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000) criteria for dementia.

Participants with a-MCI were considered to meet criteria for single domain amnestic MCI (Petersen, 2004; Petersen et al., 1999) if: (1) they expressed concern regarding their memory; (2) they performed at least 1.5 standard deviations (*SD*) below average on standardized memory tests compared to age and education-level matched controls; (3) Mini-Mental State Examination (MMSE, adjusted for age and education; Allegri et al., 1999; Folstein et al., 1975) score showed absence of global cognitive impairment (4) Clinical Dementia Rating (Morris, 1993) = 0.5. Memory Box score was at least 0.5; and (5) managed daily functioning successfully as measured by the FAQ (Functional Assessment Questionnaire; Pfeffer, Kurosaki, Harrah, Chance, & Filos, 1982) and a clinical interview.

Thirty age and education-level matched controls were recruited from among spouses and friends of patients with cognitive impairment. Controls were recruited based on specific inclusion criteria: (1) no memory complaints aside from those common to other normal participants of similar age; (2) normal memory function documented by scoring above specific cutoffs on the Rey Auditory Verbal Learning Test (RAVLT; Rey, 1941, 1964); (3) Clinical Dementia Rating = 0, with memory Box score = 0; and (4)

normal functions in activities of daily living. All controls underwent the same evaluation procedure as the patients.

Exclusion criteria for all groups included clinical (or imaging) evidence of stroke, Parkinson's disease, participants who scored Geriatric Depression Scale (GDS) > 5 (Yesavage et al., 1983), HIV/AIDS, reversible dementia, or treatment with benzodiazepines, antipsychotics, or antiepileptic medication.

The Phototest

The Phototest comprises three parts (annex 1): a naming task (30–60 seconds) with six color photographs of common objects in prototypic position (card, car, pear, trumpet, shoes, spoon); a verbal fluency test (names of people: men and women separately; 30 seconds each) demonstrated to be uninfluenced by educational level (Saez-Zea, Carnero-Pardo, & Gurpegui, 2008), and finally free recall and recall facilitated by cues using the six objects in the naming test (60–90 seconds). The test takes approximately 3 minutes to administer.

There are two parallel versions of the test. Version A is usually applied in Spain, but version B is more suitable in English-speaking countries because the first two objects in version A are virtually homophonous in English (cards, car). Phototest results are normally distributed and are not influenced by educational level (Carnero Pardo et al., 2007, 2011). It has shown good test–retest and inter-observer reliability (Carnero-Pardo et al., 2011), and various studies have reported that cutoff scores of 26/27 and 28/29 points give adequate discriminative validity for dementia and MCI, respectively (Carnero Pardo et al., 2007).

Procedure

Participants were classified as to whether or not they had cognitive impairment or dementia based on the clinical criteria (reference standard). These patients were then subjected to the screening tests. The Phototest, MMSE, and CDT were administered by a blind degreed professional trained in the administration of neuropsychology assessment, using published procedures for rating.

Phototest, MMSE and CDT were applied in the same day and under similar procedures to all participants. We used the validated version of MMSE (Allegri et al., 1999; Butman et al., 2001) in Argentina and the Freedman scoring scheme for CDT (Freedman et al., 1994). All participants were assessed with a 90-minute battery of psychometric tests including: Logical memory test of immediate and delayed recognition, Wechsler Memory Scale III (Wechsler, 1997); RAVLT (Rey, 1941, 1964); Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983); Categorical and Phonological Verbal Fluency Test (VFT; Morris et al., 1989); Digit Span Forward and Backward (Wechsler, 1997); and Trail Making Test A and B (Reitan, 1958).

Statistical analysis

Statistical analysis was performed with SPSS version 19.0 and MedCalc version 9.2 software. Demographic variables (age and education), neuropsychological battery

scores, MMSE, CDT, and Phototest scores were compared by one-way analysis of variance (ANOVA), followed by Bonferroni correction. Chi-square tests were employed for categorical data (gender). Assumption of variance homogeneity was assessed using Levene's test. In order to investigate the effects of age and education, an analysis of covariance (ANCOVA) adjusted for age and education in years followed by Bonferroni's post hoc analysis was conducted. Neuropsychological test battery scores were assessed by the raw scores of all included tests. To assess the frequency and extent of clinically relevant neuropsychological deficits, each test score of the patient group was compared with the respective norm group (control group). Measurements in patients who scored at least 1.5 *SD* below average compared to age and education-level matched controls were considered abnormal. We applied the Pearson′s correlation two-tailed analysis test to investigate the relationship between the demographic variables (age and education level) and scores on MMSE, CDT, and Phototest.

The diagnostic accuracy of the screening tests was assessed by establishing the Sensitivity (Sn) and Specificity (Sp) for the best cutoffs. Receiver operating characteristic (ROC) curve analysis was performed to evaluate discriminating power between different screening tests. Area under the curve (AUC) was used as a measure of overall ROC curve performance (95% CI). Delong's method (nonparametric analysis for correlated samples) was used to determine whether statistical differences existed in AUC values. Finally, optimal neuropsychological test cut-off points were calculated selecting the point on the ROC curve maximizing both sensitivity and specificity. A probability $p < .05$ was considered significant, and 95% confidence intervals were calculated for all study variables.

Formal aspects

This study was approved by the Internal Ethical Committee of both hospitals. After a complete description of the study to the participants and their relatives, all participants gave informed consent, or relatives gave consent on behalf of people with dementia that rendered them unable to give consent. All participants and their designated caregivers were monolingual Rioplatense-Spanish speakers. Study design and reporting complied with STARD recommendations for diagnostic test studies (Bossuyt et al., 2003).

RESULTS

Flow diagram of study participants is shown in Figure 1. Table 1 shows the sociodemographic characteristics and neuropsychological test battery results of the participants, stratified by clinical diagnosis. All participants ranged in age from 60 to 85 years ($M = 74.45$, $SD = 6.08$). The educational level varied from 1 to 19 years ($M = 9.08$, $SD = 3.98$). All of them were literate persons. A total of 71% were female. All three groups were similar with respect to age, education level, and gender. All three groups showed a continuum in their neuropsychological performance. Healthy controls displayed levels of cognitive performance within the normal range. Compared to the control group, the a-MCI group showed mainly deficits in RAVLT total score and delayed recall, category VFT, and psychomotor speed. Compared to the control and

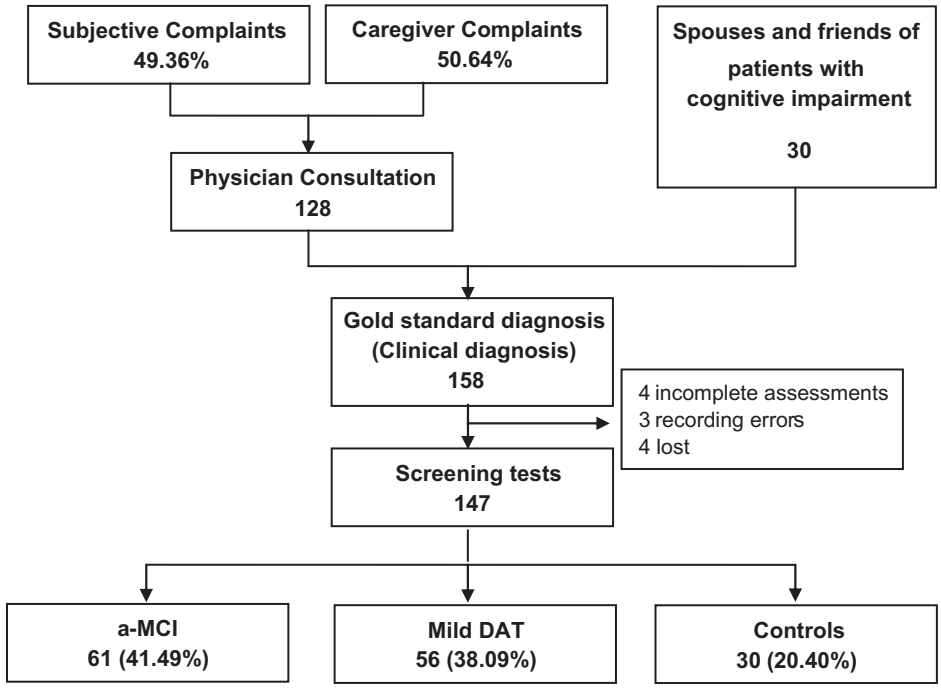

Figure 1. Flow diagram of study participants. a-MCI: amnestic mild cognitive impairment; DAT: dementia of the Alzheimer type.

a-MCI groups, the AD group showed deficits in almost all cognitive functions (episodic memory, attention, psychomotor speed, and executive function).

The groups differed significantly in screening test results in the order controls > a-MCI > DAT ($p < .001$) for the Phototest, with the exception of the MMSE and CDT scores, in which the difference between controls and a-MCI groups did not reach significance ($p = .89$ and .14). Co-varying for age or education had no effect on these results (ANCOVA results not shown).

Phototest clinical utility

The diagnostic ability of the Phototest and the comparison with MMSE and CDT were analyzed, first as a test for cognitive impairment in general (a-MCI and DAT) and then specifically for clinically diagnosed a-MCI and DAT separately.

Table 2 shows AUC, sensitivity (Sn), specificity (Sp), positive predictive value (PPV) and negative predictive value (NPV) for the best cut-off point of the Phototest, MMSE and CDT, stratified by clinical diagnosis. For discriminating between control and cognitive impairment in general (a-MCI and DAT) groups, the optimal cut-off score of Phototest was 30/31 (30 positive/ 31 negative) with a high level of Sn (89), Sp (90), and PPV (97), that of MMSE was 28/29 (Sn 85, Sp 90), and that of CDT was 6/7 (Sn 57, Sp 96). The AUC of Phototest (= .95) was significantly larger than that of the MMSE (= .84, $p = .004$) and CDT (= .77, $p < .001$).

Table 1. Demographic data and neuropsychological test battery results of the participants, stratified by clinical diagnosis

	Controls		a-MCI		DAT		ANOVA/χ^2	
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*-value[ł]
n	30		61		56			
Age (Years)	74.17	6.39	73.70	6.66	75.41	5.14	1.193	.30
Sex (M-F)	7-23		22-39		13-43		2.870	.24
Education (Years)	9.97	3.59	8.66	4.15	9.05	3.99	1.069	.34
MMSE	28.70	1.29	27.25	1.61	23.75**[a], **[b]	4.39	33.466	.00
CDT	6.97	0.18	6.31	0.78	5.14**[a], **[b]	2.21	17.503	.00
Phototest	35.43	4.94	26.74**[a]	3.67	22.02**[a], **[b]	5.16	84.715	.00
Naming	5.47	0.50	5.15	0.65	5.20	0.84	2.159	.12
Verbal Fluency Men	10.13	2.28	7.41**[a]	1.89	5.27**[a], **[b]	1.78	62.461	.00
Verbal Fluency Women	9.30	2.68	7.21**[a]	1.65	5.43**[a], **[b]	1.60	41.935	.00
Free Recall	9.67	1.74	5.62**[a]	2.36	3.93**[a], **[b]	2.70	56.311	.00
Cued Recall	0.87	0.86	1.34	0.85	2.20**[a], *[b]	1.07	22.099	.00
RAVLT Total	38.83	8.37	26.94**[a]	8.67	20.59**[a], *[b]	7.25	51.514	.00
RAVLT Delayed	7.90	2.88	2.44**[a]	2.18	1.09**[a], *[b]	2.17	82.702	.00
RAVLT Recognition	13.43	2.06	11.16	3.57	9.55**[a]	4.29	10.771	.00
Boston Naming Test	50.85	4.63	45.57	7.02	32.57**[a], **[b]	11.76	21.112	.00
Category VFT	17.54	5.21	13.90*[a]	3.92	8.57**[a], **[b]	3.06	17.268	.00
Letter VFT	15.00	5.11	12.00	3.97	6.86**[a], **[b]	3.96	13.533	.00
Forward Span	5.85	1.14	4.80	1.19	1.71	.13	1.961	.15
Backward Span	3.92	.76	3.65	.85	1.70	.53	2.041	.14
TMT-A (seconds)	44.23	16.20	83.29*[a]	16.20	120.18**[a], *[b]	74.80	9.277	.00
TMT-B (seconds)	111.38	36.02	260.00**[a]	65.59	329.54**[a], *[b]	174.50	10.651	.00

Values shown represent mean (*M*) and standard deviation (*SD*) results except for sample size and sex. Neuropsychological tests scores are represented as raw scores.

a-MCI, amnestic mild cognitive impairment; AD, Alzheimer´s disease; MMSE, Mini-Mental State Examination Test; Clock Drawing Test (CDT); RAVLT, Rey Auditory Verbal Learning Test; VFT, Categorical and Phonological Verbal Fluency Test; Forward and Backward Digit Span Subtest of WMS III; TMT, Trail Making Test A and B.

[ł]Comparisons simultaneously made among all groups using ANOVA test for all participant features but sex (χ^2 test). For features with significant differences, Bonferroni's post hoc test was made among participants for all features but sex (χ^2 test).

*$p < .05$; **$p < .001$.

[a]Significantly different from controls.

[b]Significantly different from a-MCI.

For discriminating between control and a-MCI groups, the optimal cut-off score of Phototest was 30/31 (Sn 85, Sp 90), that of MMSE was 28/29 (Sn 77, Sp 66), and that of CDT was 6/7 (Sn 50, Sp 96). The AUC of Phototest (= 0.93) was significantly higher than that of the MMSE (= .76, $p = .001$) and CDT (= .74, $p < .001$).

For discriminating between control and mild dementia groups, the optimal cut-off score of Phototest was 27/28 (Sn 89, Sp 96), that of MMSE was 27/28 (Sn 85, Sp 65), and that of CDT was 6/7 (Sn 64, Sp 96). The AUC of Phototest (= .97) was slightly but not significantly larger than that of the MMSE (= .93, $p = .116$) and was significantly larger than that of CDT (= .81, $p < .001$).

Table 2. Sensitivity, specificity, positive predictive value, and negative predictive value of total Phototest, MMSE, and CDT, stratified by clinical diagnosis

		CoP	AUC	Sn	Sp	PPV	NPV
Controls vs. All Cognitive Impairment	Phototest	≤ 30	.95 (.90 - .98)	89.74 (82.8 - 94.6)	90.00 (73.5 - 97.9)	97.2 (92.1–99.4)	69.2 (52.2–83.1)
	MMSE	≤ 28	.84 (.77–.89)	87.18 (79.7 - 92.6)	66.67 (47.2 - 82.7)	91.1 (84.2–95.6)	57.1 (39.1–73.9)
	CDT	≤ 6	.77 (.69–.83)	57.26 (47.8 - 66.4)	96.67 (82.8 - 99.9)	98.5 (92.0–100)	36.7 (26.1–48.3)
Controls vs. a-MCI	Phototest	≤ 30	.93 (.87–.98)	85.25 (73.8 - 93.0)	90.00 (73.5 - 97.9)	94.5 (84.9–98.9)	75.0 (57.8–87.9)
	MMSE	≤ 28	.76 (.66–.84)	77.05 (64.5 - 86.8)	66.67 (47.2 - 82.7)	82.5 (70.0–91.3)	58.8 (40.7–75.4
	CDT	≤ 6	.74 (.64–.83)	50.82 (37.7 - 63.9)	96.67 (82.8 - 99.9)	96.9 (83.5–99.9)	49.2 (35.9–62.5)
Controls vs. DAT	Phototest	≤ 27	.97 (.92–.99)	89.29 (78.1 - 96.0)	96.67 (82.8 - 99.9)	98.0 (89.4 - 100)	82.9 (66.1–93.6)
	MMSE	≤ 27	.93 (.86–.97)	85.71 (73.8 - 93.6)	83.33 (65.3 - 94.4)	82.5 (70.0–91.3)	58.8 (40.7–75.4
	CDT	≤ 6	.81 (.71–.88)	64.29 (50.4 - 76.6)	96.67 (82.8 - 99.9)	96.9 (83.5–99.9)	49.2 (35.9–62.5)

$n = 147$.

MMSE: Mini Mental State Examination; CDT: Clock Drawing Test; a-MCI: amnestic Mild Cognitive Impairment; DAT: mild dementia of the Alzheimer type; CoP: Cut-off point; AUC: Area under the ROC curve; Sn: sensitivity; Sp: specificity; PPV: Positive Predictive Value; NPV: Negative Predictive Value. In brackets, 95% confidence interval.

The trade-off between Sn and Sp of the Phototest, MMSE and CDT as screening tests for cognitive impairment in general, and for a-MCI and DAT separately as the cut-off point varies, is presented in three separate ROC curves. Figure 2 corresponds to all cognitive impairment, i.e., combined a-MCI and DAT versus controls; Figure 3 to a-MCI only versus controls; and Figure 4 to DAT only vs. controls.

Phototest score correlates significantly with MMSE score (= .679, $p < .001$) and CDT score (= .577, $p < .001$) (Table 3). The positive value reflects the fact that as MMSE or CDT scores increase, Phototest total scores increase, and vice versa. Only MMSE score correlated with educational level (= .157, $p = .04$).

DISCUSSION

The results of this cross-sectional phase II study of diagnostic test showed that (1) ROC statistics and standard diagnostic utility statistics were able to determine an optimum total Phototest cut-off score and provided complementary evidence for acceptable sensitivity and specificity; (2) Phototest was able to differentiate between controls and MCI/dementia groups; (3) Phototest was superior to the conventional MMSE and CDT in accuracy for identifying MCI; (4) analysis adjusted for age and education did not change the diagnostic accuracy of the Phototest; and (5) Phototest had a strong correlation with the MMSE and CDT.

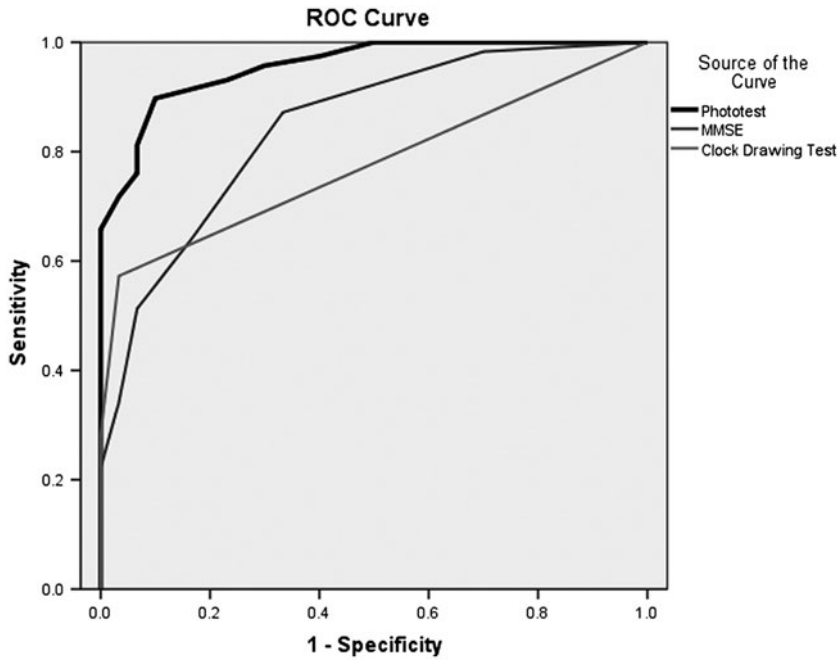

Figure 2. Comparison of ROC curves of Phototest, MMSE and CDT for cognitive impairment in general (a-MCI and DAT). MMSE: Mini Mental State Examination; CDT: Clock Drawing Test; a-MCI: amnestic Mild Cognitive Impairment; DAT: dementia of the Alzheimer type.

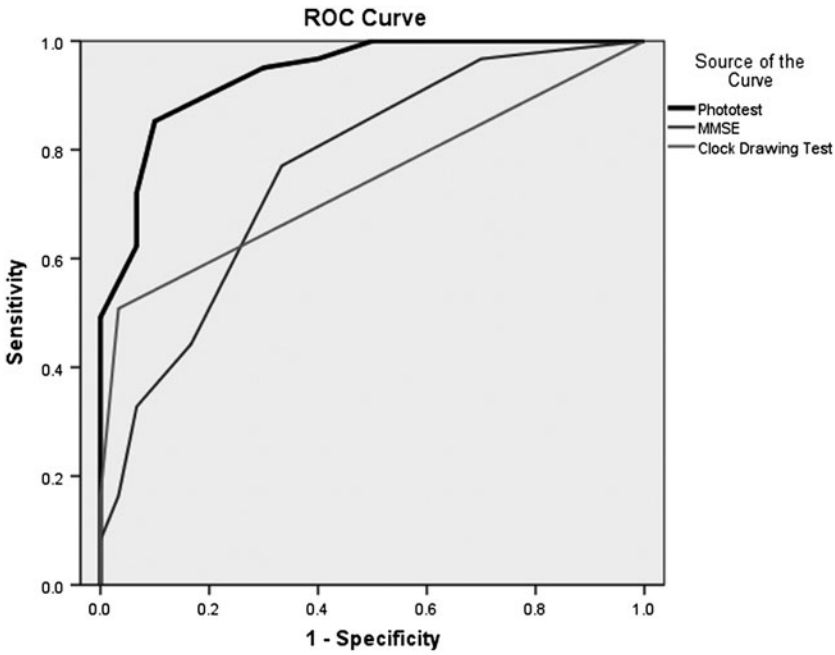

Figure 3. Comparison of ROC curves of Phototest, MMSE and CDT for a-MCI. MMSE: Mini Mental State Examination; CDT: Clock Drawing Test; a-MCI: amnestic Mild Cognitive Impairment.

Our results were equivalent to the original report (Carnero-Pardo, 2004; Carnero Pardo et al., 2007). The optimal cut-off scores for identifying MCI (30/31) and dementia (27/28) were similar to the original version (higher (29) and lower (26) cut-off scores). The Phototest total score and sub-scores of the control group were similar to each other in both studies (mean total score of our results vs. original Phototest: 35.43 vs. 33.38; mean naming subscore: 5.47 vs. 5.87; mean free recall subscore: 9.67 vs. 8.43; mean fluency men subscore: 10.13 vs. 8.63; and mean fluency women subscore: 9.30 vs. 9.33).

Phototest proved to be a sensitive and specific cognitive instrument for the diagnosis of MCI and mild dementia in our sample. Particularly for identifying MCI, Phototest was superior to the conventional MMSE and CDT in accuracy. It is widely accepted that traditional cognitive screening tests such as the MMSE do not reflect dementia severity in a reasonable manner across the broad spectrum of Alzheimer's disease, including the intermediate phase without dementia. As known, the MMSE (Folstein et al., 1975) is the most commonly used cognitive screening test. However, a meta-analysis of the accuracy of MMSE revealed its very limited value in distinguishing MCI from healthy controls (Mitchell, 2009). To meet this challenge several brief screening measures have emerged. For example, the Addenbrooke Cognitive Examination (ACE; Mathuranath, Nestor, Berrios, Rakowicz, & Hodges, 2000) has been shown to differentiate between patients with AD versus MCI (Bak et al., 2005), or the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) has been shown to be more sensitive than the MMSE in detecting MCI and mild dementia (Smith, Gildeh, & Holmes, 2007). Results in diagnostic accuracy in this study were similar to those of the original, in the MCI group (Carnero Pardo et al., 2007).

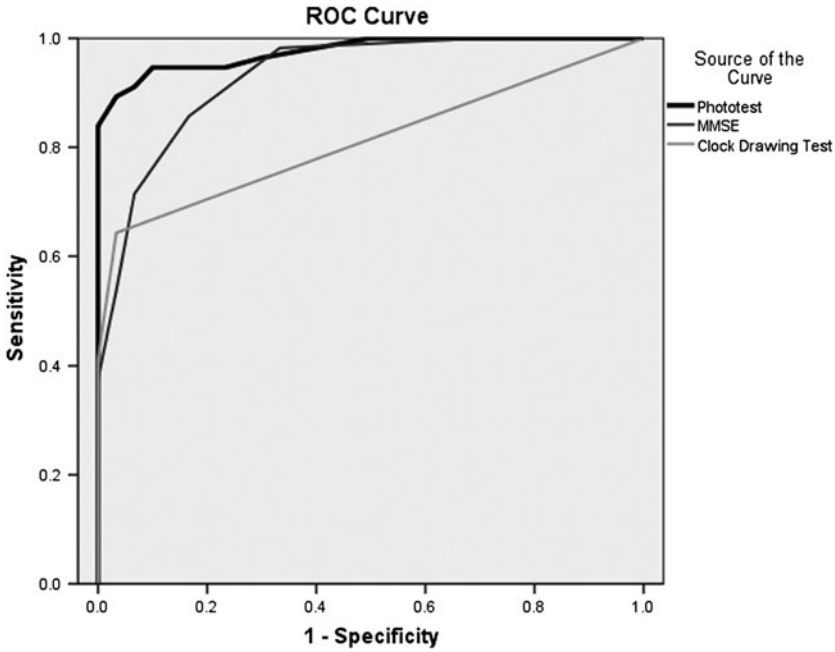

Figure 4. Comparison of ROC curves of Phototest, MMSE and CDT for DAT. MMSE: Mini Mental State Examination; CDT: Clock Drawing Test; DAT: dementia of the Alzheimer type.

Table 3. Correlations between screening tests

	Phototest	MMSE	CDT
Phototest	1	.679**	.577**
MMSE	.679**	1	.786**
CDT	.577**	786**	1

n = 147.
**p = .001 (bilateral), Pearson's correlation coefficient.

Phototest and MMSE were superior to the CDT in accuracy for detecting dementia, but both of them had equivalent diagnostic accuracies for this purpose. The AUC of the former was slightly, but not significantly, larger than that of the latter.

Although the effect of demographic parameters (age and educational level) was not directly tested, analysis adjusted for both variables did not affect the results of group comparisons and the cut-off scores in this study. The results of the current report demonstrate a strong correlation between the total Phototest score and the MMSE, a finding previously reported (Carnero-Pardo, 2004), and between the total Phototest score and the CDT. These analyses supported the criterion validity and the capacity of the total Phototest score to measure overall cognitive impairment.

The most important advantages over other available screening tests are (1) the ability to detect MCI relative to healthy controls; (2) brevity; (3) it does not require

paper and pencil; and (4) it evaluates memory and verbal fluency which are two domains affected in early DAT.

This study is not without several limitations. First, the data reported above could be enhanced with a larger normal control group, which might achieve a general cut-off score for the Phototest and correction grid scores for age and educational level (normative data). Second, absence of a measure that estimates premorbid functioning and the manner of selection which ensured that controls were cognitively intact might have favored inclusion of persons with lower cognition or preclinical dementia. Third, the current results apply only to use of the Phototest as a screening test for detection of a-MCI or mild dementia in adult clinical patients attending a memory clinic, aged 60 to 85 years and with an educational level from 1 to 19 years. Cut-off scores selected might not have the same level of discrimination in specific clinical applications because the distribution of Phototest scores in other settings (e.g., community samples) might not be equivalent to that observed in this sample. Fourth, the ability of Phototest to detect longitudinal alterations in cognitive functioning has not been tested. Finally, results correlating between biomarkers of underlying AD neuropathology and Phototest scores should be desirable. The use of a brief test such as the Phototest may improve strategies for detecting dementia in clinical practice and enrich clinical trial recruitment by increasing the likelihood that participants have underlying biomarker abnormalities. With these limitations in mind, we conclude that the Phototest is an efficient instrument for the detection of MCI and mild dementia.

SUPPLEMENTAL MATERIAL

Supplemental material for this article is available via the supplemental tab on the article's online page at http://dx.doi.org/10.1080/13854046.2014.928748.

AUTHOR NOTE

I certify that I am the corresponding author for this manuscript. The manuscript is submitted with the knowledge and on behalf of the listed co-authors.

I certify that the manuscript represents valid work and that neither this manuscript nor one with substantially similar content under my authorship has been published or is being considered for publication elsewhere, except as described in an attachment, and copies of closely related manuscripts are provided.

None of the authors has relevant financial interests related to this manuscript.

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