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Searching for the Ideal Selection of Cognitive Screening Tasks for Early Detection of Cognitive Decline in Older Individuals With Low Literacy

Isabel Pellicer-Espinosa[1] | Rafael de Andrade-Moral[2] | Unai Diaz-Orueta[3]

[1]Department of Neurology, Hospital Comarcal del Noroeste, Caravaca de la Cruz, Murcia, Spain | [2]Department of Mathematics and Statistics, Maynooth University, Maynooth, Ireland | [3]Department of Psychology, Maynooth University, Maynooth, Ireland

Correspondence: Unai Diaz-Orueta (unai.diazorueta@mu.ie)

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ABSTRACT

Background: Tests for detecting neurocognitive disorders may not be suitable for individuals with low educational levels. This study presents a battery of cognitive tests and tasks to improve the detection of cognitive decline in older adults with different literacy levels.

Method: 78 older adults attending primary care services were classified in four groups based on their educational level (low versus high) and cognitive status (healthy versus decline). The evaluation included a selection of cognitive tests and tasks administered in two orders to each half of the sample to reduce sequence of administration bias.

Results: Most tests (MMSE, Stroop, Five Digit Test, and BNT-15, as well as many individual tasks) could not differentiate properly between low-educated healthy individuals and highly educated individuals with decline, with the latter even showing better performance despite the decline in some selected tasks. The Phototest emerged as the only effective tool where healthy individuals with low education outperformed highly educated individuals with cognitive decline. A separate comparison of low versus high education groups (healthy versus decline) raised the need for differentiated tasks, based on the education level, to specifically discriminate between healthy individuals and individuals with decline.

Conclusions: Educational level (EL) significantly impacts cognitive performance. High EL individuals show better results and even compensate for cognitive decline when screened with a range of widely used cognitive tasks. Tasks must be adapted to EL to avoid biases and improve accuracy in detecting cognitive decline. Careful selection of tools based on EL is recommended to optimise cognitive assessment.

1 | Introduction

The progressive aging of the population over recent decades has led to a consequent rise in cognitive disorders. According to recent data from the World Health Organization (WHO), major neurocognitive disorder (NCD) affects more than fifty-five million people worldwide, being the seventh leading cause of death and one of the main causes of disability and dependency. Thus, it is essential to have tools for the detection of both major and mild NCD to enable early intervention in preclinical cases.

Brief cognitive screening tests (i.e., administered in less than 20 min [1]) are often used as the initial step in the evaluation of patients with suspected cognitive impairment. These screening tests can be used both by specialists and Primary Care professionals, but are not intended to confirm diagnosis on their

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own. Unfortunately, a significant proportion of the population cannot perform well on most currently available instruments because they often include tasks that require high literacy skills [2]. This "educational bias" would imply that a considerable proportion of the population falling in a range of lower education levels would be excluded from most of the instruments currently available. Different studies [3, 4] showed that performance of non-demented subjects (of a wide age range and compared by educational level) was directly affected by literacy in tasks such as naming, comprehension, verbal abstraction, orientation, figure matching, and recognition. Moreover, it was shown that schooling represented a stronger variable than age. Functional neuroimaging studies confirm that literacy modifies neural networks, such as those the brain uses for problem-solving [5]. Therefore, it is imperative to identify appropriate tools for evaluating older adults with low educational levels, which is the focus of this work.

In previous research, this team conducted a systematic literature review on the bias exhibited by various cognitive screening tests when administered to older adults with low educational attainment [6]. In that review, some conclusions could be drawn against the widespread use of some widely used screening tests such as the MMSE [7] due to the high correlation of its scores with educational level. Separately, other tests like the Phototest [8], Eurotest [8] and M@T [9] seem to work well in the assessment of individuals with low literacy. Moreover, the Five Digit Test [10, 11], a modification of the classic Stroop Test, seeks to minimise literacy bias by using numbers and quantities limited between one and five.

With all the previous considerations in mind, the goals of the current study were (1) to evaluate the feasibility of a selection of cognitive tests and tasks to capture cognitive performance in a heterogeneous sample in terms of their education level and their level of cognitive decline (already diagnosed by other means); (2) to compare performance in cognitive screening tasks that may be "educationally biased" versus matching tasks that are expected to be "unbiased" for education or literacy levels, and (3) to uncover the most suitable selection of cognitive tasks to improve the differentiation between low performance linked to cognition versus low performance linked to low literacy.

2 | Method

2.1 | Participants

The sample consisted of older adults aged 50 or more of the health and social care environment of a hospital in the region of Murcia, in southern Spain, whose primary language was Spanish. The study got the ethical approval of the hospital ethics committee where the study was held.

Exclusion criteria were major psychiatric disorders, any neurodegenerative disorder outside the scope of primary degenerative dementia, and disabling sensory disabilities (either visual or auditory, or both) that would make them incapable of performing the cognitive tests. An intentional recruitment was performed to match groups by gender, education level, and level of diagnosed decline.

The final recruited sample included 78 older adults, 41 male and 37 female individuals, with a mean age of 71.65 years (SD = 8.72). The average number of years of education for the whole sample was 6.05 (SD = 4.75), with a range from 0 to 19 years. Participants were divided into four groups, first based on their education level (less than 6 years of formal education versus six or more years), and then based on their cognitive status (healthy individuals versus individuals with cognitive decline), and matched as much as possible for age and gender to ensure a homogeneous distribution of sociodemographic variables across the groups.

Cognitive decline was determined using DSM-V criteria for both minor and major neurocognitive disorder [12] as well as with the Global Deterioration Scale (GDS) and Functional Assessment Staging (FAST) scales [13], following the diagnostic recommendations from the Spanish Society of Neurology. This categorisation based on education level and cognitive decline led to the following distribution of the sample:

1. Low level of education (< 6 years), healthy (no decline or subjective cognitive decline; GDS stage = 1 or 2), $n = 19$
2. Low level of education (< 6 years), with cognitive decline (diagnosis of minor or major neurocognitive disorder, GDS stages = 3, 4 or 5), $n = 19$
3. High level of education (≥ 6 years), healthy (no decline or subjective cognitive decline; GDS stage = 1 or 2), $n = 19$
4. High level of education (≥ 6 years), with cognitive decline (diagnosis of minor or major neurocognitive disorder, GDS stages = 3, 4 or 5), $n = 21$

Table 1 below shows the main sociodemographic information from the sample.

2.2 | Measures

Based on the results obtained from a previous systematic review performed by the authors [6], a series of cognitive screening tests and tasks already validated in the Spanish language were selected, with the aim of exploring different cognitive domains. The selection included some traditional cognitive tests with a known bias by educational level as gathered in the literature (i.e., MMSE), and some matching cognitive tests known to be less or not educationally biased (i.e., Phototest). Some tests were included in their entirety (MMSE, Phototest, BNT-15, Stroop Test and Five Digit Test), while some additional tasks were selected to cover as many cognitive domains as possible in the context of a screening stage in a primary care context.

Thus, the battery was composed initially of three tasks to determine the premorbid educational level of the patients. These could be considered proxies for literacy beyond the simple question of "how many years did you attend formal education?", which could also be a proxy or an estimate of premorbid IQ in those individuals already experiencing cognitive decline. A counting task was also included, as numeracy and literacy both rely on shared foundational cognitive abilities like working memory and verbal sequencing [14], with counting affected

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TABLE 1 | Sociodemographic variables.

	Low education level × no decline	Low education level × neurocognitive disorder	High education level × no decline	High education level × neurocognitive disorder
Gender [*n* (%)]				
Male	10 (52.6)	9 (47.4)	10 (52.6)	12 (57.1)
Female	9 (47.4)	10 (52.6)	9 (47.4)	9 (42.9)
Mean age (SD) years [Range]	72.89 (9.21) [56–87]	77.95 (5.17) [66–87]	66 (8.29) [51–80]	69.95 (7.62) [54–82]
Mean Education (SD) years	2.58 (1.68)	1.68 (1.73)	10.89 (3.93)	8.86 (2.76)

by both math and reading abilities [15]. Within this selection of tasks, the following were included:

- Word Accentuation Test or TAP [16], a Spanish adaptation of the National Adult Reading Test [17], which is used in English to evaluate general intelligence in a rapid manner (crystallised or verbal intelligence). The main variable of interest here was word accentuation accuracy.
- Saying the complete alphabet. Variable of interest: omissions of letters when remembering the alphabet.
- Counting from 1 to 20, and then from 20 to 1 in reverse order. Variables of interest: errors and omissions.

The following cognitive assessment tasks were then selected and administered in two different orders to each half of the sample, as will be described below. Full test scores as well as some performance indicators in individual tasks were collected.

- Mini Mental State Examination (MMSE) [7]
- Verbal Fluency: Semantic fluency (animals) and phonemic fluency (all the words the person can say beginning with the letter "P" in 1 min, as in the MoCA [18]). Total number of words named is counted, and the number of words able to name is collected by minute quartiles (15 s), as in the MoCA-Process-based Approach (MOCA-PA) version [19]. It is considered that performance of semantic and phonemic fluency tasks depends on lexical-semantic processes and that is related to executive functions such as working memory [20–23].
- Mental arithmetic with subtractions of seven by 7 from 100 (MoCA task), with the variable of interest being the number of successes in five subtractions.
- Clock Drawing Test (Command, Copy and Tracing versions [24, 25]). Performance error types were registered.
- Stroop Colours and Words Test [26]
- Five Digit Test [10]. Time to complete the different tasks and number of errors were collected.
- Immediate recall of Digit Forwards and Backwards, a task that is part of the Wechsler Intelligence Scale (WAIS) [27]. Three sets of direct digits (three, four, and five digits) and three sets of inverse digits (also three, four, and five digits) were selected. The following variables were registered, as in the MOCA-PA: Digits in the right order, digits in any order, total number of full series with numbers remembered in the right order, and total number of full series with numbers remembered in any order.
- Phototest [8]: This test involves naming six objects represented in photos, semantic fluency (names of the opposite sex, and of the same sex) in 30 s, and measures of delayed recall of the objects in the photos. Correct naming and recall of objects, total number of names recalled, and number of names evoked in 10-s intervals were collected.
- Boston Naming Test of 15 items (BNT-15) [28, 29]. A shortened version of the Boston Naming Test [30], widely used as a measure for the detection of difficulties and problems associated with language comprehension, naming, and expression.
- Copying drawings of the intersection of two infinite loops and of a cube (Addenbrooke's Cognitive Examination-Third Edition -ACE-III- tasks [31]). Ability to copy the drawing entirely was assessed.
- Clock Reading Test [32]: participants must read the time on 12 clocks that do not have numbers on them.
- Writing a sentence on command [33]: the patient is asked to write the sentence "I want to go home"—in Spanish (i.e., *Quiero ir a mi casa*)-. Ability to write the full sentence is registered.

2.3 | Cognitive Tasks Administration Order

Two different test and task administration orders were used (variant #1 and variant #2) with the total sample comprising four groups of participants, as shown in Table 2 below. Subsequently, half of the individuals of each of the four groups received test administration variant #1 and the other half variant #2. The main difference between the two variants was the location and order of administration of the MMSE versus the Phototest, and the Stroop Test versus the Five Digit Test, as it was determined that the previous performance on one of the tests could affect subsequent performance on the other. More specifically, the MMSE and Phototest shared a delayed free recall component (three words in the MMSE versus six images in

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TABLE 2 | Alternative variants of test administration each used with half of the sample.

	First variant of test administration	Second variant of test administration
Common part	• Interview about education level • Word Accentuation Test • Full ABC • Count from 1 to 20 • Count from 20 to 1 • Clinical scales (DSM-V and GDS-FAST)	• Interview about education level • Word Accentuation TEst • Full ABC • Count from 1 to 20 • Count from 20 to 1 • Clinical scales (DSM-V and GDS-FAST)
Alternatively administered tests	• MMSE • Verbal Fluency: letter P (phonetic) and animals (semantic) • BNT-15 • Subtract 7 from 100. • Five Digit Test • Stroop Test • Drawing ◦ Copy infinity loop ◦ Copy cube ◦ Clock Drawing (command) ◦ Clock Drawing (copy) ◦ Clock Drawing (tracing) • Clock Reading Test • Digits Forwards and Backwards • Phototest • Write a sentence (on command)	• Subtract 7 from 100. • Write a sentence (on command) • Phototest • BNT-15 • Drawing ◦ Copy infinity loop ◦ Copy cube ◦ Clock Drawing (command) ◦ Clock Drawing (copy) ◦ Clock Drawing (tracing) • Clock Reading Test • Digit Forwards and Backwards • Verbal Fluency: animals (semantic) and letter P (phonetic) • Stroop Test • Five Digit Test • MMSE

the Phototest). Despite the presentation in different stimulus modalities (verbal vs. visual), the delayed free recall task demands (i.e., having to produce items after a certain time delay) were considered similar. Hence, there was a risk that any of the tasks done first would affect or enhance the performance of the task done later. Similarly, cognitive demands posed by the Choosing section of the Five Digit Test are comparable to those by the Stroop colour-word interference task. Therefore, alternating the administration order was intended to ensure that there were no performance-boosting effects attributable to the specific administration order of the tests. However, statistical analyses performed showed no statistically significant differences attributable to being assigned to either test administration order variants.

2.4 | False Discovery Rate Correction

Due to the repeated tests and multiple comparisons that will be presented with the same groups, a False Discovery Rate (FDR) correction was performed to adjust the p values and to control the expected proportion of false positives among all declared significant results. Therefore, results presented in the remaining tables below have been adjusted using this FDR correction.

3 | Results

A preliminary overall analysis of differences between the four groups was made to identify whether there were specific full tests or individual tasks that could be discarded from any given cognitive screening protocol. Results showed that tasks not able to detect significant differences between the four groups (i.e., all $p > 0.05$) were: MMSE Immediate Memory, Naming and Commands; errors in counting 7 from 100 backwards; Five Digit Test (reading and counting errors); Stroop Word-Colour Interference task; and Phototest Naming, Fluency for same sex names, and cued recall. Moreover, none of the measures collected for the Digit Span Forward (total number of series in serial order, in any order, and individual series performance) showed any statistically significant differences between the groups assessed.

After this preliminary approach to results, we decided to structure the main results based on the following four research questions:

- Question #1: What happens when we compare cognitive performance in healthy individuals (low vs. high level of education) using traditional cognitive screening tests and tasks?
- Question #2: Is it possible to distinguish individuals with low education who are healthy from impaired individuals with high education using different cognitive screening tests and tasks? (i.e., do individuals with higher education compensate for performance despite the decline?)
- Question #3: Once we know the education level and we want to explore for decline, are there certain tasks we should not use (or emphasize the need to interpret them with caution)?
- Question # 4: Do certain tasks distinguish better between individuals with and without decline, depending on whether these individuals have a high or low level of education?

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TABLE 3 | Differences between healthy groups (low vs. high education).

Task	Results (means and SD)		*p* (FDR-corrected)	Cohen's *d*
Word accentuation test	Low ed.	3.42 (4.74)	< 0.001***	−1.37
	High ed.	14.32 (10.31)		
Alphabet omissions	Low ed.	11.42 (8.46)	< 0.001***	1.266
	High ed.	3.21 (3.54)		
MMSE score	Low ed.	26.79 (3.01)	0.024*	−0.894
	High ed.	28.84 (1.21)		
MMSE temporal orientation	Low ed.	4.26 (1.19)	0.039*	−0.723
	High ed.	4.89 (0.31)		
MMSE calculus	Low ed.	4.11 (1.29)	0.032*	−0.778
	High ed.	4.84 (0.37)		
MMSE copy drawing	Low ed.	0.58 (0.51)	0.024*	−0.936
	High ed.	0.95 (0.23)		
BNT-15	Low ed.	10 (3.43)	0.032*	−0.793
	High ed.	12.47 (2.78)		
Count 7 backwards from 100	Low ed.	2 (1.56)	0.016*	−0.995
	High ed.	3.58 (1.61)		
Five Digit Test—Time counting	Low ed.	33.94 (7.80)	0.047*	0.697
	High ed.	28.24 (8.58)		
Five Digit Test—Time choosing	Low ed.	79.78 (26.61)	< 0.001***	1.326
	High ed.	51.71 (13.13)		
Five Digit Test—Time switching	Low ed.	119.94 (62.99)	0.030*	0.887
	High ed.	74.82 (33.51)		
Five Digit Test—Errors Switching	Low ed.	4.72 (3.58)	0.032*	0.788
	High ed.	2.06 (3.15)		
Stroop test, word reading	Low ed.	71.06 (18.39)	0.032*	−0.827
	High ed.	87.41 (21.07)		
Digit forwards, 5 digits in serial order	Low ed.	3.42 (1.77)	0.039*	−0.709
	High ed.	4.53 (1.31)		
Digit backwards, 3 digits in serial order	Low ed.	1.47 (1.39)	0.032*	−0.809
	High ed.	2.42 (0.90)		
Digit backwards, 5 digits in serial order	Low ed.	1.37 (1.38)	0.032*	−0.770
	High ed.	2.58 (1.74)		

Note: *$p < 0.05$; **$p < 0.01$, ***$p < 0.001$.

3.1 | Comparison of Healthy Individuals (Low vs. High Level of Education)

A two-tailed, independent-samples *t*-test was run to estimate differences in performance between the two groups of healthy individuals (i.e., GDS 1 or 2, with no decline or just subjective cognitive decline), leading to a comparison between low-educated versus high-educated healthy individuals. Cohen's *d* was obtained to estimate the effect size of these differences, showing a large effect size for all the measures included below. As expected, a significant number of full tests and tasks showed statistically significant differences in favour of the highly educated healthy group, as shown in Table 3 below.

Separately, a further chi-square analysis was performed for the individual tasks that could not be analysed in a quantitative

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way. The goal was to establish whether higher performance was associated with higher education level. Results showed significant associations with better performance in the high education group for the ACE-III Infinity Loop Drawing ($\chi^2 = 14.148$, CC = 0.521, $p < 0.001$) and ACE-III copy cube ($\chi^2 = 22.167$, CC = 0.607, $p < 0.001$). None in the low education healthy group was able to copy the ACE-III cube, while five individuals in the high education healthy group were able to do it. For the Clock Drawing Test, the low educated healthy group showed a prominent presence of gross motor errors ($\chi^2 = 5.700$, CC = 0.361, $p < 0.05$) and conceptual errors ($\chi^2 = 4.385$, CC = 0.322, $p = 0.036$) in the command version, planning errors ($\chi^2 = 4.886$, CC = 0.338, $p = 0.027$) for the copy version and gross motor errors for the tracing version ($\chi^2 = 8.581$, CC = 0.429, $p = 0.003$). Similarly, for the Writing command, only 52.6% in the low education healthy group completed it versus 89.5% in the high education healthy group ($\chi^2 = 6.269$, CC = 0.376, $p = 0.012$).

3.2 | Comparison of Low-Education Healthy Individuals Versus Cognitively Declined Individuals With High Level of Education: Can High Education Compensate for Decline?

One of the core questions of the present study was to establish whether it is possible to distinguish between healthy individuals with low education and impaired individuals with high education levels. Previous literature [34, 35] has shown similar performance across these groups, suggesting that traditional cognitive screening tasks pose high verbal demands on low-educated individuals and benefit high-educated individuals, who can compensate for performance despite a concurrent cognitive decline.

Below, Table 4 presents three sections, respectively: (1) results for those tasks and tests where no statistically significant differences were found between these groups, (2) results in favour of the highly educated group (despite the cognitive decline), and (3) results in favour of the low-educated healthy group (which may help guide future assessment protocols for this subgroup of population).

Effect sizes are expectedly small to moderate for the first section presented in Table 4 (as these show no significant differences). There is some trend to higher effect sizes for MMSE Copy Drawing, indicating a trend to better performance, although non-significant, for the highly educated group with cognitive decline. The second section in Table 4 shows a trend (although p values show no significant differences) towards how highly educated individuals with decline perform significantly better than healthy individuals with a low education level in the Word Accentuation Test and in the Time for Choosing in the Five Digit Test. Finally, Table 4 also shows some promising results for the Phototest [8]. In this task, the low education healthy group showed a trend towards better performance, both for the global performance in the task and specifically for the delayed memory task.

Separately, a further chi-square analysis of the individual tasks that could not be analysed in a quantitative way was performed to establish whether a higher performance was associated with either of the two groups under consideration. Results showed significant associations with a better performance in the high education group with cognitive decline for the ACE-III Infinity Loop Drawing ($\chi^2 = 8.087$, CC = 0.41, $p = 0.004$) and ACE-III Copy Cube ($\chi^2 = 9.048$, CC = 0.429, $p = 0.003$). No participant in the low education healthy group was able to copy the cube, while eight in the high education group with cognitive decline were able to do it. Similarly, for the Writing command, only 53% in the low education healthy group completed it versus 90.5% in the high education decline group ($\chi^2 = 7.166$, CC = 0.39, $p = 0.007$).

3.3 | Comparison of Groups Based on Education Level: Can Certain Tests and Tasks Be Indicated or Contraindicated Once We Know the Education Level?

We tried to answer this question by considering the groups in pairs based on their level of education. Subsequently, we present the results below to address differential performance obtained in low education groups (i.e., healthy vs. cognitive decline group), followed by results for differences between high education groups. The goal was to address whether, once we know their level of education, individuals should be examined with a particularly tailored set of tests or tasks. Subsequently, we aimed to find whether certain tests or tasks should be specifically indicated (or contraindicated) for individuals with a certain level of education, in order to obtain a cognitive profile as accurate as possible.

When comparing low education groups, the hypothesis was that low education individuals with cognitive decline would show a significantly worse performance across all administered tests and tasks when compared to low education healthy individuals. For that reason, we will not focus on the large number of tests that actually showed statistically significant differences in favour of healthy individuals. Subsequently, despite results showing this outcome for the majority of administered tasks, there were two differentiated sets of tasks in which this hypothesis was not confirmed: (1) tasks in which performance was defective across all the low education groups, and (2) tasks in which performance was similarly good across all the low education groups. Table 5 shows the results for this comparison between low-educated groups, with moderate effect sizes for most of the measures.

Separately, Table 5 also shows the results for this comparison between highly educated groups. Among these, again, we leave out all administered tasks that showed statistically significant differences in favour of healthy individuals (which are a majority). Instead, we focus on tasks in which performance was similar across all the high-education groups (despite decline), with moderate effect sizes for most of the measures.

Finally, the following two sections of the results focus on the selection of tasks that may specifically be used for a more accurate screening with older adults with either a low or high level of education. The reason for this was to show, from a process-based approach point of view, which tasks were more informative about the qualitative processes involving differences in performance between healthy and impaired individuals when they have a similar educational background.

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TABLE 4 | Comparison between low educated healthy individuals and high educated individuals with cognitive decline.

Task	Results (means and SD)		*p* (FDR-corrected)	Cohen's *d*
Section 1: tasks and tests where no statistically significant differences were found between these groups				
Alphabet Omissions	Low education healthy	11.42 (8.46)	0.518	0.524
	High education decline	6.86 (8.91)		
MMSE total score	Low education healthy	26.79 (3.01)	0.680	0.241
	High education decline	25.81 (4.81)		
MMSE temporal orientation	Low education healthy	4.26 (1.19)	0.625	0.437
	High education decline	3.62 (1.69)		
MMSE spatial orientation	Low education healthy	4.89 (0.46)	0.693	0.222
	High education decline	4.76 (0.70)		
MMSE immediate memory	Low education healthy	3 (0.00)	0.680	0.301
	High education decline	2.90 (0.44)		
MMSE Calculus	Low education healthy	4.11 (1.29)	0.867	−0.064
	High education decline	4.19 (1.37)		
MMSE Delayed Memory	Low education healthy	2.37 (0.76)	0.518	0.505
	High education decline	1.86 (1.20)		
MMSE Repetition	Low education healthy	1 (0.00)	0.680	0.301
	High education decline	0.95 (0.22)		
MMSE Commands	Low education healthy	2.84	0.758	0.171
	High education decline	2.76		
MMSE Reading	Low education healthy	0.95 (0.23)	0.680	−0.333
	High education decline	1.00 (0.00)		
MMSE Writing	Low education healthy	0.74 (0.45)	0.758	−0.170
	High education decline	0.81 (0.40)		
MMSE Copy Drawing	Low education healthy	0.58 (0.51)	0.414	−0.639
	High education decline	0.86 (0.36)		
Five Digit Test: Time Reading	Low education healthy	35.39 (12.73)	0.867	0.094
	High education decline	34.20 (12.53)		
Five Digit Test: Errors Reading	Low education healthy	0.06 (0.24)	0.684	−0.242
	High education decline	0.15 (0.49)		
Five Digit Test: Time Counting	Low education healthy	33.94 (7.08)	0.721	0.208
	High education decline	32.30 (8.00)		
Five Digit Test: Errors Counting	Low education healthy	0.17 (0.51)	0.867	−0.064
	High education decline	0.20 (0.52)		
Five Digit Test: Errors Choosing	Low education healthy	2.61 (2.28)	0.680	0.353
	High education decline	1.90 (1.74)		
Five Digit Test: Time Switching	Low education healthy	119.94 (62.99)	0.680	0.281
	High education decline	104.50 (46.64)		
Five Digit Test: Errors Switching	Low education healthy	4.72 (3.58)	0.867	0.075
	High education decline	4.45 (3.66)		

(Continues)

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TABLE 4 | (Continued)

Task	Results (means and SD)		*p* (FDR-corrected)	Cohen's *d*
Verbal Fluency: Phonetic	Low education healthy	7.74 (6.01)	0.867	−0.088
	High education decline	8.24 (5.39)		
Verbal Fluency: Semantic	Low education healthy	13 (4.53)	0.680	0.254
	High education decline	11.67 (5.81)		
BNT-15	Low education healthy	10 (3.43)	0.518	0.488
	High education decline	7.90 (4.95)		
Stroop—Word reading	Low education healthy	71.06 (18.39)	0.680	−0.310
	High education decline	77.05 (20.11)		
Stroop—Colour naming	Low education healthy	49.50 (13.22)	0.993	−0.003
	High education decline	49.55 (18.23)		
Stroop—Word-Colour interference task	Low education healthy	23.25 (6.65)	0.680	−0.284
	High education decline	25.80 (10.45)		
Count 7 backwards from 100	Low education healthy	2.11 (1.53)	0.680	−0.258
	High education decline	2.52 (1.66)		
Clock Reading Test	Low education healthy	7.53 (2.67)	0.759	0.162
	High education decline	7 (3.7)		
Digits Forward: Total	Low education healthy	2.37 (0.59)	0.680	−0.299
	High education decline	2.57 (0.75)		
Digits Backward: Total	Low education healthy	0.74 (0.73)	0.518	−0.539
	High education decline	1.19 (0.93)		
Phototest: Naming	Low education healthy	5.74 (0.56)	0.680	0.253
	High education decline	5.52 (1.03)		
Phototest: Fluency, opposite sex	Low education healthy	8.42 (1.80)	0.867	0.078
	High education decline	8.24 (2.74)		
Phototest: Fluency, same sex	Low education healthy	8.84 (1.83)	0.680	0.400
	High education decline	7.81 (3.11)		
Phototest: Cued recall	Low education healthy	0.63 (0.76)	0.680	−0.317
	High education decline	0.90 (0.94)		
Section 2: Results with a trend in favour of the highly educated group (despite the cognitive decline)—non significant after the FDR correction				
Word Accentuation Test (Hits)	Low education healthy	3.61 (4.80)	0.123	−0.891
	High education decline	10.19 (9.02)		
Five Digit Test: Time Choosing	Low education healthy	79.78 (26.61)	0.111	1.043
	High education decline	57.60 (14.92)		
Section 3: Results with a trend in favour of the low educated healthy group—non significant after the FDR correction				
Phototest: Total Score	Low education healthy	34.16 (3.79)	0.414	0.663
	High education decline	30.05 (7.82)		
Phototest: Delayed Memory	Low education healthy	10.53 (1.87)	0.123	0.843
	High education decline	7.67 (4.33)		

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TABLE 5 | Comparison between group pairs based on education level (healthy vs. cognitive decline).

Task	Results (means)		*p* (FDR-corrected)	Cohen's *d*
Tasks with defective performance across the groups (low education only)				
Word Accentuation Test	Low education healthy	3.61 (4.80)	0.429	0.429
	Low education decline	1.84 (3.35)		
Alphabet Omissions	Low education healthy	11.42 (8.46)	0.825	−0.101
	Low education decline	12.32 (9.19)		
MMSE Reading	Low education healthy	0.95 (0.23)	0.429	0.468
	Low education decline	0.79 (0.42)		
Count 7 backwards from 100	Low education healthy	2.11 (1.53)	0.429	0.444
	Low education decline	1.42 (1.58)		
Tasks showing similarly good performance across the groups (low education only)				
MMSE Spatial Orientation	Low education healthy	4.89 (0.46)	0.429	0.514
	Low education decline	4.53 (0.91)		
MMSE Immediate Memory	Low education healthy	3 (0)	0.460	0.324
	Low education decline	2.95 (0.23)		
Five Digit Test—Errors Reading	Low education healthy	0.06 (0.236)	0.429	−0.442
	Low education decline	0.38 (0.236)		
Five Digit Test—Errors Counting	Low education healthy	0.17 (0.51)	0.429	−0.435
	Low education decline	0.69 (1.66)		
Five Digit Test—Time Choosing	Low education healthy	79.78 (26.61)	0.429	−0.549
	Low education decline	95.21 (30)		
Digit Backwards 5-digits—Total	Low education healthy	1.37 (1.38)	0.493	0.280
	Low education decline	1 (1.25)		
Phototest Naming task	Low education healthy	5.74 (0.56)	0.429	0.390
	Low education decline	5.47 (0.77)		
Tasks showing similar performance across the groups (high education only)				
Word Accentuation Test	High education healthy	14.42 (10.31)	0.429	0.438
	High education decline	10.19 (9.02)		
Alphabet Omissions	High education healthy	3.21 (3.54)	0.429	−0.528
	High education decline	6.86 (8.91)		
MMSE Spatial Orientation	High education healthy	5	0.429	0.469
	High education decline	4.76 (0.70)		
MMSE Immediate Memory	High education healthy	3	0.460	0.301
	High education decline	2.90 (0.44)		
MMSE Repetitions	High education healthy	1	0.460	0.301
	High education decline	0.95 (0.22)		
MMSE Reading	High education healthy	1	—	—
	High education decline	1		
MMSE Commands	High education healthy	2.84 (0.50)	0.760	0.154
	High education decline	2.76 (0.54)		

(Continues)

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TABLE 5 | (Continued)

Task	Results (means)		*p* (FDR-corrected)	Cohen's *d*
MMSE Writing	High education healthy	0.84 (0.37)	0.825	0.084
	High education decline	0.81 (0.40)		
MMSE Copy Drawing	High education healthy	0.95 (0.23)	0.460	0.296
	High education decline	0.86 (0.36)		
Verbal Fluency—Phonetic	High education healthy	10.84 (4.60)	0.429	0.517
	High education decline	8.24 (5.40)		
Five Digit Test—Time Reading	High education healthy	28.76 (11.05)	0.429	−0.458
	High education decline	34.20 (12.53)		
Five Digit Test—Errors Reading	High education healthy	0	0.429	−0.416
	High education decline	0.15 (0.49)		
Five Digit Test—Time Counting	High education healthy	28.24 (8.58)	0.429	−0.491
	High education decline	32.30 (8.01)		
Five Digit Test—Errors Counting	High education healthy	0.06 (0.24)	0.460	−0.337
	High education decline	0.15 (0.49)		
Five Digit Test—Time Choosing	High education healthy	51.71 (13.13)	0.429	−0.417
	High education decline	57.6 (14.92)		
Five Digit Test—Errors Choosing	High education healthy	1.76 (1.44)	0.825	−0.084
	High education decline	1.90 (1.74)		
Stroop—Word reading	High education healthy	87.41 (21.07)	0.429	0.504
	High education decline	77.05 (20.11)		
Stroop—Colour naming	High education healthy	55.47 (12.83)	0.448	0.370
	High education decline	49.55 (18.23)		
Stroop—Word-Colour interference task	High education healthy	26.71 (10.40)	0.825	0.087
	High education decline	25.80 (10.45)		
Digit Forwards—Total	High education healthy	2.84 (0.37)	0.429	0.451
	High education decline	2.57 (0.75)		
Digit Backwards—Total	High education healthy	2 (0.74)	0.807	0.126
	High education decline	1.90 (0.54)		
Phototest Naming task	High education healthy	5.84 (0.37)	0.429	0.402
	High education decline	5.52 (1.03)		
Phototest—Fluency—Same sex	High education healthy	9.16 (2.19)	0.429	0.497
	High education decline	7.81 (3.11)		
Phototest—Cued recall	High education healthy	0.63 (0.68)	0.460	−0.329
	High education decline	0.90 (0.94)		

3.4 | Distinction Between Healthy Versus Decline: Which Tasks Work Better With Low- Educated Individuals?

Based on the chi-square analyses run on tasks that could not be analysed numerically, in low-educated individuals, counting 20 to 1, six words from the BNT-15 and planning errors in the command version of the Clock Drawing Test seem to be the best to distinguish between healthy and impaired individuals in our sample. First, for Counting 20 to 1: 89.5% of healthy individuals vs. 57.9% of individuals with decline were able to complete the task ($\chi^2 = 4.886$, CC = 0.338, $p = 0.027$). Second, for BNT-15, the ability to name

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specifically these 6 out of 15 words (#2 (sharpener), #5 (muzzle), #10 (muffin), #11 (cactus), #13 (dart) and #15 (parchment): all CC between 0.33 and 0.36, $p < 0.05$) was associated with belonging to the low-educated healthy group. Third, for Clock Drawing command version errors, 73.69% in the low-education healthy group made errors versus 100% in the low-education group with cognitive decline ($\chi^2 = 5.758$, CC = 0.363, $p = 0.016$), and, among them, planning errors were the most frequent in the low-education decline group.

3.5 | Distinction Between Healthy Versus Decline: Which Tasks Work Better With Highly Educated Individuals?

Based on the chi-square analyses run on tasks that could not be analysed numerically, in high-educated individuals, ACE-III copy cube task, 12 out of 15 specific words of the BNT-15, and gross motor errors in both the command and the copy version of the Clock Drawing Test seem to be the best to distinguish between healthy and impaired individuals in our sample. First, for ACE-III copy cube task, 73.7% in the high-education healthy individuals completed the task correctly, versus 36.4% of the high-education decline group ($\chi^2 = 5.105$, CC = 0.336, $p = 0.024$). Second, for the BNT-15, 12 out of 15 words (all except #6 (pegs), #8 (rhinoceros) and #11 (cactus)) were correctly named by the healthy individuals (all CC between 0.297 and 0.429, $p < 0.05$). Third, for the Clock Drawing Test, command version, 42.1% in the high-educated healthy made errors versus 85.71% in the high-educated decline group ($\chi^2 = 8.338$, CC = 0.415, $p = 0.004$), while for the Clock Drawing Test, tracing version, 5.2% in the high-educated healthy group made errors versus 33.33% in the high-educated decline group ($\chi^2 = 4.912$, CC = 0.331, $p = 0.027$). In both clock drawing modalities, gross motor errors were the most frequent among the cognitive decline group.

4 | Discussion

The overall aim of this study derived from the concern for whether it was possible to use a single test, not relying on or being biased by literacy skills, which would be sufficient to distinguish between low performance caused by cognitive decline and low performance caused by low education or low literacy levels. With this aim in mind, the first goal of the current study was to evaluate the ability of a selection of cognitive tests and tasks to capture cognitive performance accurately, in a sample of older adults with different education levels and different levels of cognitive decline (already diagnosed by other means). A preliminary analysis of the results already identified some specific tests and tasks that did not show any differences between individuals from the four groups that were created -based on their level of education (low versus high) and their cognitive status (healthy versus decline). Every measure from the Digit span forward and certain items from MMSE (Immediate Memory, Naming and Commands); errors in counting 7 from 100 backwards; Five Digit Test (reading and counting errors); Stroop Word-Colour Interference task; and Phototest (Naming, Fluency for same sex names, and cued recall) did not show any differences between the four groups. This suggests that these tasks may not be informative enough and that, possibly, they should be discarded by clinicians or, at least, by front-line healthcare providers (i.e., general practitioners in primary care) who have limited time constraints to develop relevant cognitive screening sessions with their patients.

From that preliminary overall approach, we decided then to structure the study with the aim of answering four research questions.

First, we wanted to identify differences in cognitive performance just in healthy individuals (divided into two groups: low vs. high level of education). Results presented in Table 3 show that, when healthy individuals are divided based on their level of academic attainment, many tools used in traditional cognitive screening show a significantly better performance in individuals with high education level. Specific tasks used to assess premorbid IQ, such as the Word Accentuation Test and Alphabet omissions, were among these tools showing a bias in favour of highly educated individuals, as expected. The MMSE, questioned in the literature as highly biased by education, also showed a better performance in the high education group, both as a full test but also in selected tasks (temporal orientation, arithmetic, and copy drawing). However, our findings differ from previous studies [11, 28], as BNT-15 and several Five Digit Test measures (counting and choosing times, and shifting time and errors) showed better performance in highly educated individuals despite the absence of cognitive decline. This discrepancy may partly reflect differences in educational variability across samples. Calero et al. [28] found no significant effect of education on BNT-15 performance, but noted that their sample was relatively homogeneous in its low educational attainment and that an educational effect might have emerged if individuals with higher education had been included. Similarly, De Paula et al. [11] studied the FDT primarily in a predominantly low-educated sample. Our broader educational range may therefore have allowed education-related differences to become more apparent.

Second, we wanted to distinguish the performance of low-educated healthy individuals from impaired individuals with high education. This is the core question of this study, and as shown in previous literature (Ardila et al.; Nielsen et al. [34, 35]) there were significant problems in finding relevant tasks that could properly differentiate between low-educated healthy individuals and high-educated individuals with cognitive decline. Results showed no significant differences between these two groups for the whole MMSE (both taken as a whole test and when each task was analysed), most of the measures of Five Digit Test; phonetic and semantic fluency; the whole Stroop test; the Clock Reading test; Digit Backwards and some individual tasks from the Phototest (Naming, fluency for same sex and opposite sex names, and cued recall). Exceptions to this lack of differentiation between groups were found, but in two opposite directions.

On the one hand, the high education group with decline, despite the cognitive decline, was still able to perform better in the Word Accentuation Test (which could be expected) but also in the time invested in the Choosing subtask of the Five Digit Test. The Word Accentuation Test is a task that measures premorbid IQ and is a proxy measure for education level in Spanish speaking

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countries [36, 37], similar to the National Adult Reading Test (NART) in English speaking countries [38]. Separately, the Time for Choosing task in the Five Digit Test is a task in which high-educated individuals also perform better despite the decline, suggesting that it is a task with a higher executive demand and less reliant on potentially defective memory problems that older adults with decline may have in the initial stages of MCI and dementia. A separate analysis of ACE-III drawing tasks and other writing tasks showed similar results in favour of the high education group with decline.

On the other hand, only the Phototest taken as a whole test, and the Delayed Memory task (which uses visually presented material instead of verbal material as the MMSE) were the only scores that appeared to show a trend in favour of the low-education healthy group when compared with the high-education group with decline. The Phototest has already been described in previous systematic reviews [6] as an option for cognitive screening with low education and low literacy groups, which specifically relies on visually presented stimuli that the participants need to remember, instead of the usual paradigm of word retrieval that may provide an advantage to individuals with a high education level. However, apart from the Phototest, most of the measures for older adults with high education seemed to mask their performance or at least perform in a way that is not distinguishable from healthy individuals with low education level, which poses serious concerns on the selection of the most appropriate tasks to screen for cognitive decline in early stages of a neurodegenerative disease.

Third, once education level is known, we wanted to identify tasks that we should not use (or at least, interpret with caution) when screening for cognitive decline. As expected, most of the tests used presented significantly higher scores for healthy individuals when compared with those with cognitive decline, once the education level was known. At this point, we wanted to focus more on those tasks that could not be numerically analysed. It was expected that these tasks, from the point of view of a process-based approach to cognitive performance, could provide more detailed information to distinguish between healthy and impaired individuals with a similar educational background. Subsequently, results showed, for both low and high education groups, that tasks presented in Table 5 should be avoided, as they may not be accurate enough to capture differential performance attributable to cognitive decline in these groups, once the level of education is known.

Finally, we wanted to know whether certain tasks distinguished better between individuals with and without decline, and whether these tasks are the same or different depending on whether we are comparing low or high-educated individuals. In low-educated individuals, counting 20 to 1, six words from the BNT-15 and the number of planning errors in the command version of the Clock Drawing Test seem to be the best to distinguish between healthy and impaired individuals in our sample. Finally, in high-educated individuals, the ACE-III copy cube task, 12 out of 15 specific words of the BNT-15, and gross motor errors in both the command and the copy version of the Clock Drawing Test seemed to be the best to distinguish between healthy and impaired individuals in our sample.

This research has obvious limitations. Despite the Phototest showing a trend that would recommend it as "the" test to screen older adults with low literacy, results are not strong enough to support such a recommendation. Even tasks like the BNT-15, theoretically without an education level bias, did not show a consistent ability to distinguish more clearly between defective performance due to cognitive decline and defective performance attributable to literacy. With regards to this, the problem may also relate to the probably inappropriate consideration of educational attainment as a proxy for literacy skills. There is no clear consensus in the reviewed literature, even when we performed a previous systematic review on this topic [6], on how to accurately define education level and how to (1) distinguish education from literacy, or (2) use education as a proxy for literacy. For differentiating between high and low education level, our previous review showed diverse arbitrary cut-points depending on the study (over versus less than six school years; over versus less than eight school years; differentiation between illiterate, primary, secondary and tertiary studies, etc.). In addition, estimates of literacy, usually associated with premorbid IQ, are very much dependent on the language and culture (e.g., Word Accentuation Test versus NART), and internationally agreed batteries like the WAIS are not appropriate for a short, time limited, screening process. Moreover, formal education years do not allow us to distinguish whether low performance in cognitive tests is due to literacy, familiarity with academic-like tasks, subsequent professional/occupational performance, daily life cognitive stimulation (leisure activities or hobbies), or other socio-cultural factors. We performed, though, an approach to assessment of literacy and related numeracy skills with the Word Accentuation Test, the Alphabet and counting from 1 to 20 forwards and backwards, although conclusions obtained are limited. This poses a limitation to our study, as groups were selected using formal education years as a proxy for literacy, which needs further refinement in future studies. In terms of the sample size, this is a preliminary study that would require further validation with a larger sample size to obtain more robust data. Moreover, the cognitive "decline" in the groups was heterogeneous, but due to the sample size, no further subgroups could be made (e.g., differentiating between GDS 3, 4 and 5), which led to a comparison study between groups with and without cognitive impairment. In terms of the study design, the sample was intentionally recruited, and measures were administered once. Finally, the statistical analyses shown here are just an initial approach to the data; beyond mean comparisons and chi-squares, prediction and classification models and machine learning tools (using tree-based methods, such as Random Forests and the Boruta algorithm, combined with cross-validation) are being used (Pellicer-Espinosa et al., in preparation) to establish the accuracy of selected tests and tasks to classify each individual into their right group. It is expected that these more robust analyses will provide a more accurate picture of the tasks and tests more appropriate for screening of cognition in individuals across different education levels.

Future steps will demand moving beyond exam-like tasks when evaluating individuals with low education levels. In addition, the relevance of visually presented stimuli (like in the Phototest) versus verbal materials when evaluating individuals

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with low education level needs to be considered. Another test that could have strengthened the results from this perspective is the Free and Cued Selective Reminding Test (FCSRT) [39, 40]. As an additional point of interest from the expanded search, the FCSRT [39] has shown diagnostic precision in individuals with low educational attainment. While a word-based version (FCSRT-Word) also exists, the use of images is pivotal for individuals with limited literacy, as it relies on cognitive domains less influenced by formal education, such as semantic memory. Finally, moving from paper and pencil exam-like tasks to virtual reality-based environments that would allow creating tasks and tests that are more relevant for the daily life functioning of all individuals [41], but especially of those with low education level, would definitely need further consideration in the quest to properly distinguish between performance attributable to cognitive decline without, or at least minimising, the influence of educational background.

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The authors have nothing to report.

Ethics Statement

The study was approved by the Clinical Research Ethics Committee of the Virgen de la Arrixaca University Hospital in Murcia (Spain) (Reference number 2022-6-6-HCUVA).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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