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# Comparative Analysis of MoCA and DigiMoCA Test Results: A Pilot Study

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**Featured Application: The implementation of targeted interventions focusing on specific cognitive domains affected by depression and cognitive impairment, ultimately enhancing the overall cognitive health and well-being of older adults.**

**Abstract:** This study examined the cognitive performance of older adults aged 60 and above using the Montreal Cognitive Assessment (MoCA) test and DigiMoCA, a digital tool for cognitive screening administered by means of a smart speaker, to investigate whether the additional variables utilised by DigiMoCA allow for the identification of significant differences between individuals with depressive symptoms and those with mild cognitive impairment, which are not detected using the original MoCA test. A total of 73 senior adults located in Northwestern Spain, 22 male and 51 female, participated in this study. Subjects were divided into four groups based on the presence of depressive symptoms and mild cognitive impairment, with the aim of analysing the results of each dimension of the MoCA and DigiMoCA tests and assessing the additional insights provided by the digital administration tool. The results indicate significant differences among groups. Individuals with depressive symptoms exhibited poorer performance in forward number span, attention, and clock drawing compared to healthy controls. Furthermore, individuals with depressive symptoms and mild cognitive impairment exhibited significantly worse memory and orientation compared to those with cognitive impairment alone. Correlations revealed that a greater severity of depressive symptoms was associated with poorer performance across cognitive domains, including visuospatial skills, attention, language, memory, and phonemic verbal fluency. This study also illustrated how the exploitation of additional variables systematically captured by digital instruments, such as completion times or response delays to individual interactions, may facilitate the early identification of cognitive and depressive conditions, providing initial evidence about the importance of integrating advanced digital tools in cognitive assessment to inspire the development of more effective, personalised interventions.

**Keywords:** clock drawing test; cognition assessment; depression; DigiMoCA; digital administration; mild cognitive impairment; MoCA



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## 1. Introduction

As a consequence of aging, a number of emotional, physical, and social challenges are faced by senior adults that may increase their vulnerability to developing mood disorders, such as depression. Not only does this disorder negatively affect the quality of life of elder adults, but it can also have a significant impact on their cognitive and functional ability,

which can make it even more difficult for them to actively participate in their communities and maintain social and family relationships.

Early studies about this topic focused primarily on demonstrating that depressed and non-depressed people differ in the content of their thoughts. These investigations provided support for the formulation that depression is characterised by negative automatic thoughts and biases in attention, interpretation, and memory [1,2]. The deterioration of processing speed and executive, attentional, and amnestic functions are frequent findings [3], and, as a consequence, cognitive symptoms such as difficulty in concentrating or slowness in thinking and decision making are among the diagnostic criteria included in the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) for major depressive disorder (MDD) [4].

Late-life depression refers to depression that occurs in individuals aged 65 and above without a prior history of depression. Unlike early-onset depression, late-life depression in the elderly often presents with less prominent symptoms of sadness, particularly when characterised by cognitive deficits as the primary symptom, can be mistaken for dementia in older adults. Therefore, it is essential to conduct a thorough mental status examination and cognitive testing before reaching a definitive diagnosis [5–8].

A systematic review conducted by John A. and colleagues in 2019 [9] comprehensively analysed and synthesised the evidence regarding the relationship between affective problems and cognitive decline in older adults. This multilevel meta-analysis revealed a significant association between depression, assessed both as a binary and continuous predictor, and the decline in cognitive status. Deficits in various domains, including attention, executive functions, memory, and processing speed were among the symptoms most frequently reported by patients and their relatives. These disorders often tend to persist even during the remission of depressive symptoms [10]. These deficits are thought to be clinically relevant and seem to be in the same order of magnitude of deficits observed in other well-known disorders involving cognitive dysfunction (e.g., mild cognitive impairment, attention-deficit hyperactivity disorder) [11,12].

Digital technology has been demonstrated to have a great impact on cognitive assessment and health care [13], as it facilitates repeated and continuous assessments, as well as the collection of clinical data in a much more convenient and cost-effective way than paper-and-pencil assessments [14]. Some previous research efforts have addressed innovative solutions for the screening of mental health disorders, specially depression, by means of voice interaction only, utilising both commercial and experimental devices [15].

In this context, the DigiMoCA, an implementation of the phone version of the Montreal cognitive assessment test (T-MoCA) as a skill for Amazon's Alexa, was developed as a proof of concept to illustrate the implementation of scripted conversations by means of off-the-shelf smart assistants for the screening of cognitive impairment [16]. The DigiMoCA utilises Alexa's speech recognition and natural language understanding (NLU) services, adapting the speech rate to the user with prosodic annotations, collecting user responses to the test, as well as additional variables not captured with the original test (e.g., response times, delays, voice level), and storing sessions for future retrieval in Amazon's persistent database system. A pilot study was conducted where the DigiMoCA was evaluated in terms of (i) performance, evidencing that it understands the user 90% of the time; (ii) usability and acceptability, with average scores in the Technology Acceptance and Post-Study System Usability questionnaires over 3/5 and 5/7, respectively; and (iii) validity, with a correlation factor with a T-MoCA of $r = 0.88$ and an area under the ROC curve of 0.79 for MCI detection.

The motivation of this research originated from the evidence obtained with the study referenced above [16], which provided initial evidence that the DigiMoca may enhance the precision and efficiency of cognitive assessments by providing standardised administration and scoring, consequently reducing the impact of confounding factors like the white-coat effect, human errors, and variability. Digital platforms based on smart assistants also incorporate adaptive conversation techniques, which become adaptive testing techniques in this context, tailoring the difficulty of tasks to the subject's performance, which may result

in more accurate and personalised assessments. Additionally, these tools greatly facilitate the collection of rich, real-time data both on cognitive dimensions and the testing process itself (e.g., response times, delays, etc.), enabling more comprehensive and detailed analysis. In fact, our experience with machine learning analysis [17] helped us to identify patterns and changes in cognitive function that were not adequately addressed by traditional methods. Additionally, digital tools may improve accessibility to cognitive evaluations, allowing for remote administration and monitoring, which is particularly beneficial for older adults who may have mobility issues or live in rural areas. To sum up, the adoption of intelligent agent-based cognitive tests has the potential to improve the early detection, diagnosis, and ongoing management of MCI, ultimately enhancing the quality of care for the elderly.

This research aimed to provide a comprehensive assessment of cognitive dimensions using the MoCA in groups of individuals with depressive symptoms (DSs) and MCI, while also exploring the added value that the digital administration tool DigiMoCA may offer in the collection and analysis of cognitive data. More specifically, this study aimed to respond to the following research question:

> RQ: Do the additional variables utilised by the DigiMoCA allow for the identification of significant differences between individuals with depressive symptoms and those with mild cognitive impairment (MCI) that are not detected through the original MoCA test?

## 2. Materials and Methods

An overview of this study's design is discussed below, including a detailed description of the study participants, as well as the criteria for participant inclusion and exclusion. In order to ensure the validity and reliability of the findings, rigorous criteria were employed to determine the eligibility of individuals. A description of the study sample is also provided, offering insight into the demographic characteristics, medical history, and other relevant factors of the participants involved in this research. Finally, the measurement instruments utilised and the statistical analysis approach are briefly discussed.

### *2.1. Participants and Procedures*

A total of 73 participants were individually tested using the MoCA and 15-item Yesavage Geriatric Depression Scale (GDS-15) to confirm a previous diagnosis of MCI or depression and configure study groups. All participants also completed the Lawton and Brody scale and the Clock Drawing Test (CDT). A subsample of 57 of these individuals participated in a second session carried out through two weeks after the first evaluation, in which they were administered the DigiMoCA. Participants were recruited from Parque Castrelos and Os Cortizos day centers and through publicly displayed recruitment materials. All participants provided informed consent prior to participating in this study. The study protocol was previously approved by the Galician Ethics Committee (2023/503). Figure 1 summarizes the study procedure.

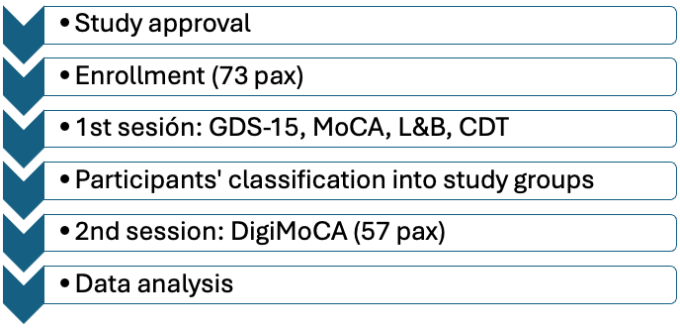


**Figure 1.** Study protocol. Participants were recruited from daycare centers in the Vigo area, NW Spain. All sessions took place in their respective care centers.

The inclusion criteria utilised to select the participants in this study are enumerated below. These criteria served also as a reference to define the groups under study.

**D+MCI+** Senior individuals with depressive symptoms and MCI. Subjects with a depression diagnosis (MDD) confirmed by a health professional or previous clinical history; a Yesavage Geriatric Depression Scale (GDS-15) score greater than 5 (indicative of depression); a MoCA score 1.5 deviations below the population mean according to age and educational levels (i.e., level 3 in Reisberg's Global Deterioration Scale, GDS).

**D+MCI−** Persons with depressive symptoms that do not exhibited cognitive decline. Individuals with MDD reported by a health professional or previous clinical history; a GDS-15 score greater than 5; a MoCA score within the parameters of normality according to age and educational levels (i.e., GDS 1).

**D−MCI+** Subjects not exhibiting depressive symptoms but with MCI. No diagnosis of depression; a GDS-15 score less than or equal to 5; a MoCA score 1.5 deviations below the average.

**D−MCI+** Control group involving persons not exhibiting depressive symptoms or MCI. No diagnosis of depression; a GDS-15 score less than 5; a MoCA score between 1.5 deviations below the population mean (Reisberg's GDS 3).

All participants were 60 years of age or older and were located in the Vigo area, Spain. The exclusion criteria below were applied:

- Patients with a psychiatric diagnosis, different from the inclusion criteria for groups D+ MCI+ and D+ MCI−.
- Dementia diagnosis.
- Hearing or vocal disability.
- People unable of consenting to the study.

Subjects enrolled in daycare centers for the elderly provided the needed clinical diagnosis details for their classification, while participants external to the day centers were classified according to the cut-off points of the GDS-15 and MoCA scales. In the latter case, a more accurate cut-off point was utilised, according to the normative data in [18].

Participants ranged in age from 60 to 99 years, with an average age of 75.78 ± 9.2 years. Of the total number of participants, 30% (22) were male and 69.9% (51) female. From them, 28.8% (21) had depressive symptoms and MCI, 13.7% (10) had depressive symptoms without MCI, 17.8% (13) had MCI without depressive symptoms, and 39.7% (29) were healthy individuals without MCI or depressive symptoms. The participants' distribution in the study groups and the descriptions of the sociodemographic variables are presented in Table 1.

**Table 1.** Participants' sociodemographic characteristics.

| | | **D+MCI+ n = 21** | **D+MCI− n = 10** | **D−MCI+ n = 13** | **Healthy n = 29** | **n = 73** |
|---|---|---|---|---|---|---|
| Educational level | <12 | 95.2% (20) | 80% (8) | 69.2% (9) | 44.8% (13) | 50 |
| | >12 | 4.8% (1) | 20% (2) | 30.8% (4) | 55.2% (16) | 23 |
| Household | LA | 33.3% (7) | 20% (2) | 15.4% (2) | 31% (9) | 20 |
| | LWO | 66.7% (14) | 80% (8) | 84.6% (11) | 69% (20) | 53 |
| Marital status | Married | 23.8% (5) | 50% (5) | 46.2% (6) | 44.8% (13) | 29 |
| | Single | 14.3% (3) | – | – | 6.9% (2) | 5 |
| | Widowed | 61.9% (13) | 50% (5) | 46.2% (6) | 27.6% (8) | 32 |
| | Divorced | – | – | 7.7% (1) | 20.7% (6) | 7 |
| Sex | Male | 28.6% (6) | 30% (3) | 46.2% (6) | 24% (7) | 22 |
| | Female | 71.4% (15) | 70% (7) | 53% (7) | 75.9% (22) | 51 |
| Age (Mean) | 75.78 ± 9.2 | 81.90 ± 9.1 | 74.00 ± 8.1 | 76.46 ± 9.2 | 71.66 ± 7.3 | 75.78 ± 9.2 |

LA: living alone. LWO: living with others.

A sample size of 73 participants may not provide sufficient statistical power to detect subtle effects, especially when divided into four groups. However, as discussed in the rest of this paper, the results obtained demonstrate that this sample is sufficient for shedding some light about the applicability of digital instruments based on smart assistants for cognitive assessment in elder adults. On the other side, the geographical area where participants were enrolled do not have significant demographic, cultural, or socio-economic characteristics that make it singular when compared with other urban-rural areas in Western Europe, although its applicability in other areas of the world is not clear. In any case, the sample reasonably reflects the distribution of male and female individuals in the general population of that age in Western Europe (i.e., between 60 and 99 years).

### 2.2. Measures

MoCA [19] is a test designed to assess cognitive function in older adults. It evaluates various cognitive domains including attention, memory, language, visuospatial abilities, executive functions, and orientation by means of a series of tasks and questions that are completed in approximately 10–15 min, with a maximum score of 30 points. A score of 26 or above is generally considered normal cognitive performance, while lower scores may indicate cognitive impairment. The MoCA is valued for its sensitivity in detecting early cognitive decline and is used in both clinical settings and research to assess cognitive function in older adults and those suspected of having cognitive deficits. It is available in multiple languages and has been validated across diverse populations, making it a versatile and reliable tool for cognitive assessment.

The GDS-15 [20] (Geriatric Depression Scale) is a scale used to detect symptoms of depression in older adults. This 15-item questionnaire simplifies the original 30-item scale while maintaining its effectiveness. Each item is answered with a simple *yes* or *no*, reflecting the respondent's feelings over the past week. The total score ranges from 0 to 15, with higher scores indicating more severe depressive symptoms. A score of 5 or more typically suggests the presence of depression, warranting further evaluation. The GDS-15 is valued for its ease of use, quick administration time, and suitability for individuals with cognitive impairments, making it a widely used tool in both clinical and research settings to assess depression in the elderly.

Lawton & Brody's Instrumental Activities of Daily Living [21] is a scale used to assess functional independence in activities of daily living in older adults. It assesses eight domains, namely, using the telephone, shopping, food preparation, housekeeping, laundry, transportation, medication management, and handling finances. Each activity is scored based on the level of assistance required, ranging from complete independence to complete dependence, with higher scores indicating greater independence. This scale is widely used in both clinical and research settings to assess the functional capabilities of elderly individuals, identify those in need of assistance, and plan appropriate interventions to support independent living.

The Clock Drawing Test (CDT [22]) is an assessment instrument utilised to measure visuospatial and executive abilities. A scoring scale is used that assigns a maximum of 2 points for the accuracy in drawing a clock dial; 4 points for the correct placement of numbered hour markers, and 4 points for the proper position of clock hands [23]. This scale allows for a detailed quantitative assessment of the individual's ability to perform the task.

The DigiMoCA [16] is a cognitive impairment screening test powered by a conversational agent, which is based on the telephone version of the MoCA (T-MoCA). The DigiMoCA collects data of the following cognitive tasks using an intelligent conversational agent: letter mistakes, letter points, forward and backward number span, the number of correct subtractions (referred to as calculations), and the score obtained from subtraction tasks (referred to as subtractions), the number of F words spoken (referred to as F words), word punctuation, the variable first sentence and the variable second sentence (correct repetitions of sentences), transportation and measurement abstraction tasks, uncued recall, cued recall, choice recall, and orientation for month, year, week, organisation, and city.

These tasks can be grouped as in the original T-MoCA test in five dimensions, namely, attention, language, abstraction, memory, and orientation. In this study, it was decided to analyse these dimensions using mean comparison tests. This eventually facilitated the consolidation of all the data collected by the DigiMoCA into factor groupings with stronger associations, thereby facilitating analysis.

### 2.3. Statistical Analysis

Statistical analyses were carried out using SPSS Statistics 24 software (International Business Machines, S.A., Madrid, Spain). Descriptive statistics were obtained for each of the sociodemographic variables included in the study, and also for the MoCA, CDT, and DigiMoCA scores. An analysis of variance (ANOVA) was performed on the three tests' scores to estimate the effect size through the $\eta^2$ statistic. Descriptive statistics provided a clear and concise overview of the data, allowing for initial observations about the central tendencies and variability within each group. The ANOVA extended this analysis by testing for statistically significant differences between the means of the different groups and provided data to estimate the effect size.

A Kolmogorov normality analysis [24] was conducted to assess the suitability of the distributions of the variables under study. Non-parametric Kruskal–Wallis [25] and Mann–Whitney U [26] tests were performed to compare groups in the absence of normality and homogeneity of variances assumptions. The Kruskal–Wallis statistic was applied in scenarios involving three or more groups, while the Mann–Whitney U test was used for comparisons between two groups. The Kolmogorov–Smirnov normality analysis, Kruskal–Wallis, and Mann–Whitney U tests were deemed appropriate for this study due to the specific characteristics of the data and the research question addressed. The Kolmogorov–Smirnov test helped us to assess whether the distribution of the variables deviated from a normal distribution, ensuring the correct application of statistical methods. Given that our data did not meet the assumptions of normality and homogeneity of variances, non-parametric tests were necessary. The Kruskal–Wallis test was suitable for comparing more than two groups, as it evaluates whether there are statistically significant differences in the median scores across multiple independent groups without assuming a normal distribution. Similarly, the Mann–Whitney U test was considered appropriate for comparing groups and determining if their distributions differed significantly. These non-parametric tests are robust against violations of normality and provided reliable results for comparing group differences.

Principal Component Analysis (PCA [27]) was employed with the variables collected through the DigiMoCA. This method was utilised to reduce the dimensionality of the data and uncover underlying patterns among the variables of the digital test, facilitating subsequent correlation analyses. The variance explained by each component was examined, and a Scree plot was generated to visualise the optimal number of components to retain. A rotated component matrix was computed to identify relationships among variables and summarise the information into a more manageable set of principal components.

Finally, Spearman correlation analyses [28] were conducted between the original variables and the factors extracted from the PCA, providing a detailed insight into the relationships and associations observed in the dataset. Since PCA reduces the dimensionality of the dataset and identifies underlying factors, it was considered key to understand how these factors correlate with the original variables. Additionally, the Spearman correlation, being a non-parametric method, is robust to outliers and non-normal distributions, making it well suited for diverse data characteristics. This analysis provided valuable insights into the associations between the extracted factors and the original variables, revealing patterns and relationships that inform the interpretation of the PCA results and enhance the overall understanding of the dataset.

The confidence interval defined for the calculated statistics was 95% in all cases. Due to the exploratory nature of our study, the use of robust non-parametric methods, the focus on PCA, the sample size constraints, and the comprehensive analytical approach taken, a

power analysis was omitted from this study and left for future research, where a power analysis can be appropriately integrated to confirm the observed patterns and relationships.

## 3. Results

Tables 2–4 present the mean values and standard deviations for each of the tests and variables assessed by means of the tests, and ANOVA's $\eta^2$ statistic to provide a measure of effect size. The most relevant differences are discussed and explained in the following paragraphs.

**Table 2.** Means and standard deviations of tests by classification group.

| | D+MCI+ | D+MCI− | D−MCI+ | Healthy | $\eta^2$ |
|---|---|---|---|---|---|
| MoCA | (21) 13.0 ± 4.7 | (10) 21.4 ± 5.0 | (13) 16.3 ± 3.7 | (29) 24.0 ± 3.5 | 0.514, $p < 0.001$ |
| DigiMoCA | (15) 7.20 ± 3.8 | (9) 9.40 ± 4.5 | (10) 8.20 ± 3.2 | (23) 11.1 ± 3.7 | 0.164, $p = 0.022$ |
| CDT | (19) 5.80 ± 2.5 | (10) 7.20 ± 2.8 | (11) 5.70 ± 2.9 | (29) 12.2 ± 16.7 | 0.262, $p = 0.001$ |

(Number of subjects) Mean ± Std. Dev.; CDT: clock drawing test.

**Table 3.** Means and standard deviations for each cognitive group in the MoCA test by classification group.

| | D+MCI+ n = 21 | D+MCI− n = 10 | D−MCI+ n = 13 | Healthy n = 29 | $\eta^2$ |
|---|---|---|---|---|---|
| Total score (0–30) | 13.0 ± 4.7 | 21.4 ± 5.0 | 16.3 ± 3.7 | 24.0 ± 3.5 | 0.514, $p < 0.001$ |
| Attention | 2.38 ± 1.4 | 4.30 ± 1.3 | 3.00 ± 1.7 | 5.21 ± 1.1 | 0.503, $p < 0.001$ |
| Language | 0.81 ± 0.9 | 1.80 ± 0.8 | 1.38 ± 0.8 | 2.34 ± 0.8 | 0.345, $p < 0.001$ |
| Abstraction | 0.71 ± 0.8 | 1.50 ± 0.5 | 1.08 ± 0.6 | 1.52 ± 0.6 | 0.217, $p = 0.004$ |
| Orientation | 4.14 ± 1.6 | 5.70 ± 0.7 | 5.08 ± 1.6 | 5.79 ± 0.4 | 0.175, $p = 0.016$ |
| Memory | 0.38 ± 0.7 | 1.60 ± 1.4 | 1.15 ± 1.0 | 2.14 ± 1.6 | 0.199, $p = 0.008$ |
| VE/Executive | 1.24 ± 1.4 | 2.80 ± 1.5 | 1.85 ± 1.3 | 3.76 ± 1.4 | 0.288, $p < 0.001$ |
| Identification | 2.24 ± 0.8 | 2.80 ± 0.5 | 2.15 ± 0.7 | 2.90 ± 0.4 | 0.201, $p = 0.007$ |

VE: Visuospatial.

**Table 4.** Means and standard deviations for each cognitive group in the DigiMoCA test by classification group.

| | D+MCI+ n = 15 | D+MCI− n = 9 | D−MCI+ n = 10 | Healthy n = 23 | $\eta^2$ |
|---|---|---|---|---|---|
| Total score (0–22) | 7.20 ± 3.8 | 9.40 ± 4.5 | 8.20 ± 3.2 | 11.1 ± 3.8 | 0.164, $p = 0.022$ |
| Response time | 1.29 ± 0.2 | 1.02 ± 1.4 | 5.70 ± 3.0 | 1.04 ± 0.1 | <0.001, $p = 0.109$ |
| Attention | 2.20 ± 1.1 | 2.56 ± 1.4 | 3.10 ± 1.3 | 3.39 ± 1.5 | 0.127, $p = 0.064$ |
| Language | 1.07 ± 1.2 | 1.89 ± 1.1 | 1.30 ± 0.8 | 1.78 ± 0.8 | 0.118, $p = 0.082$ |
| Abstraction | 0.20 ± 0.4 | 0.22 ± 0.4 | 0.50 ± 0.7 | 0.65 ± 0.7 | 0.107, $p = 0.108$ |
| Orientation | 2.47 ± 1.3 | 2.33 ± 1.1 | 2.10 ± 0.9 | 3.04 ± 1.1 | 0.105, $p = 0.115$ |
| Uncued recalls | 0.33 ± 0.9 | 1.67 ± 2.1 | 0.60 ± 1.4 | 1.78 ± 1.9 | 0.152, $p = 0.032$ |
| Cued recalls | 0.80 ± 1.1 | 1.67 ± 1.6 | 1.40 ± 1.5 | 1.39 ± 1.2 | 0.055, $p = 0.390$ |
| Choice recalls | 1.47 ± 1.3 | 1.11 ± 0.6 | 0.80 ± 0.6 | 1.43 ± 1.3 | 0.051, $p = 0.425$ |
| Forward numbers | 0.67 ± 0.5 | 0.56 ± 0.5 | 0.90 ± 0.3 | 0.96 ± 0.2 | 0.165, $p = 0.022$ |
| Backward numbers | 0.80 ± 0.4 | 0.67 ± 0.5 | 0.80 ± 0.4 | 0.83 ± 0.4 | 0.000, $p = 0.810$ |
| Letter mistakes | 9.73 ± 9.1 | 3.22 ± 2.4 | 5.20 ± 7.3 | 2.13 ± 1.4 | 0.243, $p = 0.002$ |
| Letter | 0.13 ± 0.4 | 0.33 ± 0.5 | 0.30 ± 0.5 | 0.48 ± 0.5 | 0.046, $p = 0.184$ |
| Calculations | 0.67 ± 1.0 | 1.33 ± 1.7 | 1.20 ± 1.2 | 1.35 ± 1.4 | 0.851, $p = 0.472$ |
| Subtractions | 0.60 ± 0.8 | 1.00 ± 1.1 | 1.10 ± 1.0 | 0.74 ± 1.0 | 0.052, $p = 0.411$ |
| First sentence | 0.47 ± 0.5 | 0.78 ± 0.4 | 0.40 ± 0.5 | 0.91 ± 0.4 | 0.103, $p = 0.122$ |
| Second sentence | 0.47 ± 0.5 | 0.78 ± 0.4 | 0.70 ± 0.5 | 6.00 ± 0.3 | 0.166, $p = 0.021$ |
| F_words | 4.27 ± 4.3 | 6.78 ± 4.1 | 6.20 ± 4.2 | 0.13 ± 3.6 | 0.052, $p = 0.416$ |
| Words p | 0.13 ± 0.4 | 0.33 ± 0.5 | 0.20 ± 0.4 | 0.74 ± 0.3 | <0.001, $p = 0.571$ |
| Transport | 0.20 ± 0.4 | 0.11 ± 0.3 | 0.20 ± 0.4 | 0.43 ± 0.5 | <0.001, $p = 0.195$ |
| Measure | 0.00 ± 0.0 | 0.11 ± 0.3 | 0.30 ± 0.5 | 0.22 ± 0.4 | <0.001, $p = 0.171$ |
| Day guess | 0.53 ± 0.5 | 0.33 ± 0.5 | 0.20 ± 0.4 | 0.43 ± 0.5 | <0.001, $p = 0.401$ |
| Month guess | 0.87 ± 0.4 | 0.78 ± 0.4 | 0.70 ± 0.5 | 0.96 ± 0.2 | <0.001, $p = 0.230$ |
| Year guess | 0.13 ± 0.4 | 0.00 ± 0.0 | 0.00 ± 0.0 | 0.00 ± 0.0 | <0.001, $p = 0.125$ |
| Week guess | 0.47 ± 0.5 | 0.67 ± 0.5 | 0.40 ± 0.5 | 0.83 ± 0.4 | 0.138, $p = 0.048$ |
| Organization | 0.27 ± 0.5 | 0.33 ± 0.5 | 0.40 ± 0.5 | 0.26 ± 0.4 | <0.001, $p = 0.866$ |
| City guess | 0.20 ± 0.4 | 0.22 ± 0.4 | 0.40 ± 0.5 | 0.57 ± 0.5 | 0.111, $p = 0.098$ |

The obtained eta squared values and $p$-values indicate varying degrees of effect sizes and statistical significance for the MoCA, DigiMoCA, and CDT in relation to cognitive performance among the study groups. In the case of the MoCA, this suggests a very strong effect size, indicating that a significant portion of the variance in cognitive performance is explained by the MoCA scores. DigiMoCA's $\eta^2$ suggests a moderate effect size, showing that the DigiMoCA scores explain a reasonable, though smaller, portion of the variance in cognitive performance compared to the MoCA. For the CDT, it indicates a moderate to strong effect size. The $p$-values obtained suggest a robust association between test scores and the cognitive performance of participants. Overall, these results demonstrate that all three tests—the MoCA, DigiMoCA, and CDT—are significant predictors of cognitive performance, with the MoCA showing the strongest effect, followed by the CDT and then the DigiMoCA.

With respect to the MoCA dimensions, the $\eta^2$ values suggest varying degrees of effect sizes, ranging from moderate (e.g., orientation or memory) to very strong in the case of attention.

In the case of the DigiMoCA, the larger effect sizes correspond to calculations and letter mistakes, while the effect sizes of the response time, words, transport, measure, day guess, month guess, year guess, and organisation are the smallest. These results further inspired us to conduct a factor analysis, as discussed below.

A Kruskal–Wallis analysis was performed among the groups, finding significant differences ($p < 0.025$) among all groups on the DigiMoCA's global score; MoCA's visuospatial, identification, attention, language, abstraction, memory, and orientation; DigiMoCA's forward numbers, letter mistakes, second sentence, and uncued recalls; and finally, clock drawing. No differences were found in the time responses among groups.

A Mann–Whitney U analysis was also carried out for each combination between groups:

**D+/MCI+ vs. D−/MCI+** presented differences in MoCA's memory and orientation. Individuals with depressive symptoms and MCI displayed significantly poorer performances in memory and orientation compared to subjects without depressive symptoms but with MCI.

**D+/MCI+ vs. D+/MCI−** showed significant differences in various cognitive domains as assessed through the MoCA: visuospatial, identification, attention, memory, and orientation. Individuals with depressive symptoms and MCI exhibited poorer performances compared to those with MCI alone.

**D+/MCI− vs. D−/MCI+** differed significantly only in identification. Participants with depressive symptoms exhibited better performances compared to those without symptoms but with MCI.

**D+/MCI+ vs. D−/MCI−** exhibited significant differences across multiple cognitive tasks, namely, the DigiMoCA's forward numbers, letter mistakes, second sentence, uncued recalls; MoCA's visuospatial, identification, attention, language, abstraction, and memory; clock drawing; and DigiMoCA's attention and abstraction. The group of individuals with MCI and depressive symptoms exhibited poorer performances across all cognitive tasks, with a higher number of letter mistakes.

**D−/MCI+ vs. D−/MCI−** displayed significant differences in various cognitive measures: MoCA's visuospatial, identification, attention, language, and abstraction; clock drawing; and DigiMoCA's orientation. Individuals in the MCI group exhibited poorer performances in all mentioned cognitive tasks compared to the healthy group.

In order to explore the correlations among all variables, a principal component analysis was conducted using the variables obtained from the DigiMoCA to categorise them into factors and gain a better understanding of their underlying structure. This approach enabled the identification of patterns and relationships among variables, thereby facilitating correlation analysis. Initially, the Kaiser–Meyer–Olkin (KMO) and Bartlett tests yielded a KMO mean of 0.604 (cf. Table A1, Appendix A). Upon the examination of the

table of communalities (cf. Table A2, Appendix A), it was noted that the extraction of variables transport, day, and organization increased the KMO mean to 0.668, resulting in communalities exceeding 0.4 for the remaining variables.

Table A3 in Appendix A displays the distribution of the DigiMoCa variables into seven factors, which explain 73.7% of the total variance. In Figure 2, a Scree plot depicts the variables that determine the number of factors to retain in an exploratory factor analysis.

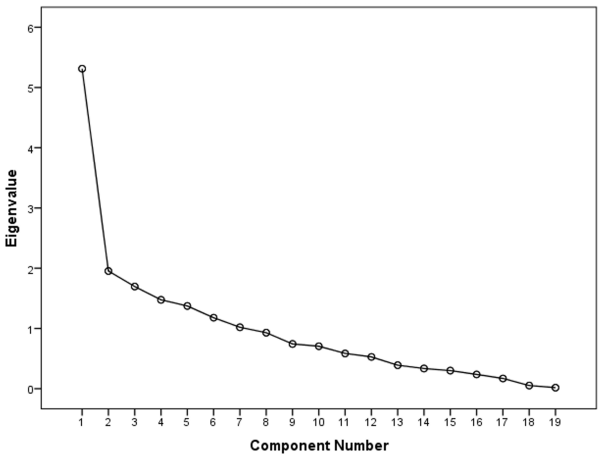


**Figure 2.** Scree plot depicted to identify the variables that determine the number of factors to retain in an exploratory factor analysis.

Finally, Varimax was used in the present study as the most common rotation technique in statistical analysis. Table A4 in Appendix A presents Varimax-rotated components exhibiting the relationship between the original variables and the components derived from the principal component analysis. Each number in the table reflects the loading of individual variables onto each component, resulting in seven distinct factors, namely, factor 1 (calculations, subtraction, words, and F words), factor 2 (letter mistakes, letters, second sentence, and week), factor 3 (mean response time, uncued recalls, first sentence), factor 4 (backward numbers, forward numbers, and month), factor 5 (choice recalls and measure), factor 6 (year), and factor 7 (city and cued recalls).

The Spearman correlation analysis was employed to assess the relationships among sociodemographic variables (i.e., age, gender, educational level, residency, marital status). Furthermore, associations between MoCA test scores and dimensions, as well as DigiMoCA factors with the GDS-15 scale, are highlighted, considering only values close to or exceeding 0.3 (cf. Table 5). No correlations greater than 0.3 were found for the sex variable.

**Table 5.** Spearman correlations.

| | | GDS-15 | RT Mean | Age | Ed. Level | Household |
|---|---|---|---|---|---|---|
| CDT | Total score | −0.469, $p < 0.001$ | −0.355, $p = 0.007$ | −0.660, $p < 0.001$ | 0.513, $p$ <0.001 | – |
| MoCA | Visuospatial/FE | −0.429, $p$ <0.001 | −0.437, $p = 0.001$ | −0.709, $p < 0.001$ | 0.510, $p < 0.001$ | – |
| | Identification | – | – | −0.375, $p = 0.001$ | 0.426, $p < 0.001$ | – |
| | Attention | −0.447, $p < 0.001$ | −0.324, $p = 0.014$ | −0.466, $p < 0.001$ | 0.525, $p < 0.001$ | – |
| | Abstraction | – | −0.341, $p = 0.009$ | −0.494, $p < 0.001$ | 0.466, $p < 0.001$ | – |
| | Language | −0.391, $p = 0.001$ | – | −0.403, $p < 0.001$ | 0.453, $p < 0.001$ | – |
| | Memory | −0.301, $p = 0.010$ | 0.478, $p < 0.001$. | −0.463, $p < 0.001$ | 0.463, $p < 0.001$ | – |
| | Orientation | – | – | −0.428, $p < 0.001$ | 0.428, $p < 0.001$ | – |
| | Total score | −0.422, $p < 0.001$ | −0.482, $p < 0.001$ | −0.684, $p < 0.001$ | 0.524, $p < 0.001$ | – |
| DigiMoCA | Factor 1 | – | – | – | 0.308, $p = 0.020$ | −0.296, $p = 0.025$ |
| | Factor 2 | −0.321, $p = 0.015$ | – | −0.508, $p < 0.001$ | 0.371, $p = 0.005$ | – |
| | Factor 3 | – | −0.861, $p < 0.001$ | −0.426, $p = 0.001$ | – | – |
| | Factor 6 | – | – | – | – | – |
| | Total score | – | −0.641, $p < 0.001$ | −0.665, $p < 0.001$ | 0.382, $p = 0.003$ | – |
| Lawton's | Total score | −0.367, $p = 0.001$ | −0.324, $p = 0.014$ | −0.582, $p < 0.001$ | – | – |

**GDS-15** correlates negatively with the CDT score, visuospatial, attention, language, overall MoCA score, memory, and factor 2. These negative correlations suggest that, as scores on the GDS-15 scale increase, indicating relevant depressive symptoms, scores on these cognitive measures tend to decrease. Furthermore, a significant positive correlation was observed between the GDS-15 and Lawton and Brody's, indicating that as depressive symptoms increase, functional dependency also increases, as assessed using the Lawton and Brody scale.

**Response time** correlates negatively with the CDT and MoCA and more strongly with the visuospatial, attention, language, abstraction, and memory MoCA dimensions, and positively with age. Additionally, it also correlates with the DigiMoCA's global score and with the DigiMoCA's factor 3. Overall, these correlations indicate that the cognitive task performance tends to decrease as the average response time increases, particularly in tasks related to visuospatial ability, attention, language, abstraction, and memory. Additionally, the CDT and MoCA total scores also exhibit negative correlations with the response time. On the other hand, as age increases, so do the execution times.

**Age** correlates negatively with the CDT, total MoCA score, and all its dimensions: visuospatial, attention, language, identification, abstraction, memory, and orientation. Lawton and Brody's scores correlate positively with age. Additionally, correlations were found with the DigiMoCA's total score and its factors 2 and 3. As age increases, there is a tendency toward a cognitive and functional performance decline, as evidenced by negative correlations with various cognitive and functional measures. Additionally, positive correlations with age were found in the Lawton scale, indicating a higher level of functional dependence with increasing age. Similarly, correlations with the DigiMoCA and its factors suggest age-related decline in the cognitive assessment performance by means of the digital instrument.

**Educational level** positively correlates with the CDT; MoCA's visuospatial, identification, attention, language, and abstraction; Lawton and Brody's score; MoCA's total score; and DigiMoCA's factor 2. A higher educational level is associated with better performance in the cognitive MoCA dimensions mentioned, and in factors 1 and 2 of the DigiMoCA. On the other hand, residence correlates negatively with factor 1 ($r = -0.296$, $p = 0.025$). This correlation suggests that individuals who live alone tend to have higher scores on factor 1 compared to those who live with others.

## 4. Discussion

The results obtained revealed significant differences among groups. These results are consistent with previous research, such as that of Meniert et al. [29], where it was found that patients with depressive symptoms showed significantly worse results compared to healthy controls in all neuropsychological tests included in their study (i.e., verbal fluency, processing speed, executive functioning, sustained attention, long- and short-term memory performance, visuospatial working memory, verbal working memory, and verbal fluency). Cognitive impairments are an important aspect of MDD [30,31], although not all subjects report the same differences, for example in attention or language [30].

Our data show that individuals with depressive symptoms exhibited differences in forward numbers, attention, and clock drawing performance compared with the healthy control group, evidencing the progressive loss of cognitive faculties measured through the MoCA when comparing these two groups. The most affected dimensions are visuospatial skills, memory, attention, and language; however, only significant differences in attention were found. Language ($p = 0.053$) and visuospatial skills/EF ($p = 0.054$) have significance values close to 0.05. On the other hand, the CDT used to assess executive and visuospatial ability showed a significant differentiation between both groups, demonstrating worse performances for people with depressive symptoms [32].

We can find in the literature studies that demonstrate that MDD is reliably associated with poor performances on neuropsychological measures of executive function, with effect

sizes ranging from 0.32 to 0.97 [33,34]. In fact, it can be argued that difficulties in executive functioning and visuospatial memory are the best predictors of depression in the elderly [35]. Our study evidences poorer performances as depressive and MCI symptomatology increases, with a notable decrease in all domains of cognitive performance compared to the other groups. In fact, the correlation values obtained confirm identifying patterns between depressive symptomatology and cognitive variables, thus indicating that relevant depressive symptoms imply poorer performances in visuospatial skills, including the CDT, attention, language, memory, and DigiMoCA's factor 2, which include letter mistakes, letters, second sentence, and week guessing [36].

The group of people with depressive symptoms only did not show significant differences compared to those with MCI, except for the identification variable, where the former had a better performance.

In addition, the results obtained indicate that individuals with DS and MCI show significantly poorer performances in memory and orientation compared to those without depressive symptoms exhibiting mild cognitive impairment. The onset of depressive symptoms aggravates deficits in memory and orientation in people with MCI, as some studies have previously suggested [3,37–40]. On the other hand, when the D+/MCI+ and D+/MCI− groups were compared, significantly poorer performances in visuospatial skills, identification, attention, memory, and orientation were observed in individuals with depressive symptoms and MCI with respect to those with depressive symptoms (D+ MCI−). This suggests that the presence of MCI aggravated cognitive deficits in multiple areas, such as executive/visuospatial skills, attention, and identification [41].

When comparing the group of healthy individuals with those with DS and MCI, significant differences were observed in all cognitive tasks, as expected, in favour of the group of healthy individuals. It is important to note that the DigiMoCA only reveals differences in total scores and in attention and abstraction. On the other hand, when comparing the group of healthy individuals with those who only have MCI, the number of significant variables is reduced, highlighting the executive functions, identification, attention, language, and abstraction provided by the MoCA, as well as the orientation variable of the DigiMoCA (i.e., questioning the subject about the year in which the session occurred). This was attributed to discrepancies in the collection of results from the digital assessment method, which experienced capture problems in this specific variable (i.e., the average value was equal to zero in the year variable between both groups). These capture problems were due to a technical bug in the smart speaker's code when providing the outcomes of this specific question in the DigiMoCA.

The means of the most relevant variables concerning the DigiMoCA can be observed in Table 4. Regarding completion times, a trend can be observed indicating that subjects with MCI tend to require more time compared to those without cognitive problems, or only with depressive symptoms. Despite this, no significant differences were observed in the means between groups. In some studies, patients with depression had a slower processing speed compared to the control group [33].

It can also be pointed out that the data obtained in this research evidence significantly negative correlations between completion times, the CDT and MoCA performances, especially in its visuospatial dimensions, attention, language, abstraction and memory. The slowing-down process associated with age is also highlighted, reflected in the increase in the average completion time [42,43].

Finally, age is negatively correlated with the CDT and MoCA and all its dimensions (i.e., visuospatial/executive functions, attention, language, identification, abstraction, memory, and orientation), and the educational level is positively correlated with these same cognitive variables, indicating better cognitive performances in these tasks as age advances, in the case of subjects with more education and a worse performance.

This study, while providing valuable insights into the cognitive impacts of depressive symptoms and MCI, has several limitations that need to be acknowledged. The sample size of 73 participants, with a subsample of 57 for the DigiMoCA assessment, is relatively small,

potentially limiting the generalisability of the findings to broader populations. While our study provides valuable preliminary insights, the sample size means that findings should be interpreted with caution, and further research with larger samples will be necessary to validate and expand upon our conclusions.

The use of self-report measures, such as the GDS-15 and the Lawton and Brody scale, introduces the possibility of response bias, where participants may under-report or over-report their symptoms and functional abilities. Additionally, the cross-sectional design of this study precludes any causal inferences regarding the relationship between depressive symptoms, MCI, and cognitive performance. Furthermore, the multiplicity of analyses conducted increases the risk of type I errors, where significant findings could occur by chance. Despite these limitations, the overall findings remain robust and provide meaningful contributions to our understanding of the complex interplay between mental health and cognitive functioning and the use of state-of-the-art digital screening instruments. The patterns observed in the data are consistent with the existing literature, and the associations identified offer valuable directions for future research.

Thus, while the present study followed the design of a pilot study, it remains highly relevant and valuable for advancing our understanding of the interplay among depressive symptoms, MCI, and cognitive performance. As a preliminary investigation, this study provides important foundational data and highlights key areas of cognitive impairment associated with depressive symptoms and MCI, offering relevant insights for future research. Despite its limitations, including a relatively small sample size, the findings contribute to the growing body of the literature by identifying significant cognitive deficits in this population. Moreover, the innovative use of the DigiMoCA demonstrates the potential for digital tools to enhance cognitive assessment, paving the way for more comprehensive and nuanced evaluations in larger-scale studies. Consequently, this pilot study could serve as an important step toward more extensive research, emphasising the need for continued exploration in this field to develop targeted interventions and improve the overall well-being of older adults with depressive symptoms and cognitive impairments.

## 5. Conclusions

Our findings suggest that the DigiMoCA provides a more detailed assessment of cognitive performance across various domains, including attention, memory, executive function, visuospatial skills, and language. Notably, individuals who participated in this study with depressive symptoms showed significant impairments in tasks such as forward numbers, attention, and clock drawing compared to the healthy control group. Furthermore, a progressive decline in cognitive abilities was observed with increasing levels of depressive symptoms and MCI, affecting all cognitive domains assessed.

The results indicate that depressive symptoms are associated with poorer performances in visuospatial skills, attention, language, and memory. Importantly, individuals with both depressive symptoms and MCI demonstrated significantly worse performances in memory and orientation than those with only MCI, and also showed poorer performances in visuospatial skills, identification, attention, and memory compared to those with only depressive symptoms.

These findings suggest that the DigiMoCA is a useful tool for uncovering nuanced cognitive deficits linked to depressive symptoms and MCI that the original MoCA might not detect. In any case, this study highlights the importance of integrating advanced digital tools in cognitive assessment to facilitate the early identification of cognitive and depressive conditions and to inspire the development of more effective, personalised interventions. To sum up, there is initial evidence that the DigiMoCA may contribute to enhancing our understanding of the complex interplay between depression and cognitive decline, providing a comprehensive approach to cognitive assessment.

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L.A.-R. and M.J.F.-I.; data curation, N.L.-P.; writing—original draft preparation, N.L.-P. and M.J.F.-I.; writing—review and editing, all authors; visualisation, N.L.-P., M.J.F.-I. and I.O.-G.; supervision, L.A.-R.; project administration, L.A.-R.; funding acquisition, L.A.-R. All authors have read and agreed to the published version of the manuscript.

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**Institutional Review Board Statement:** This study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of Galicia, Spain (protocol code 2023/503), approved on 23 January 2024.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in this study.

**Data Availability Statement:** The raw data utilised in this study are available upon request to the corresponding author. The data are not publicly available due to privacy.

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## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| CDT | Clock Drawing Test; |
| DigiMoCA | MoCA—Digital Version; |
| DS | Depressive Symptom; |
| DSM-5 | Diagnostic and Statistical Manual of Mental Disorders, 5th ed.; |
| GDS | Global Deterioration Scale; |
| GDS-15 | Yesavage Geriatric Depression Scale; |
| MCI | Mild Cognitive Impairment; |
| MoCA | Montreal's Cognitive Assessment Test; |
| PCA | Principal Component Analysis; |
| SPSS | Statistical Package for the Social Sciences; |
| T-MoCA | MoCA—Telephone version. |

## Appendix A. Additional Tables

This Appendix contains several tables that provide additional detailed information regarding the principal component analysis (PCA) conducted in this study. Table A1 presents the results of the Kaiser–Meyer–Olkin (KMO) test and Barlett's sphericity test conducted after the extraction of principal components. These tests assess the adequacy of the data for the PCA, with the KMO test indicating the sampling adequacy of the variables and Barlett's test evaluating whether the correlation matrix is significantly different from an identity matrix. Table A2 displays the communalities in the DigiMoCA obtained from the PCA, indicating the proportion of variance in each variable explained through the extracted factors. Table A3 presents the total explained variance from the distribution of the DigiMoCA variables into seven factors, providing insights into the cumulative proportion of variance accounted for by each factor. Lastly, Table A4 presents the rotated component matrix, offering a comprehensive summary of the relationships among variables and factors after rotation, facilitating the interpretation of the underlying structure of the data obtained from the PCA. These tables complement the main findings of the study by providing a

deeper understanding of the PCA results and the underlying structure of the DigiMoCA assessment.

**Table A1.** Kaiser–Meyer–Olkin and Barlett's sphericity tests after extraction.

| KMO's | Sampling adequacy index | 0.668 |
|---|---|---|
| Barlett's | Chi-square (approx.) | 566.418 |
| | gl | 171 |
| | *p* | <0.001 |

**Table A2.** Communalities in DigiMoCA obtained from principal component analysis.

| | **Initial** | **After Extr.** |
|---|---|---|
| Forward number span | 1.000 | 0.641 |
| Backward number span | 1.000 | 0.786 |
| Letter mistakes | 1.000 | 0.765 |
| Letter | 1.000 | 0.573 |
| Calculations | 1.000 | 0.928 |
| Substractions | 1.000 | 0.902 |
| First sentence | 1.000 | 0.713 |
| Second sentence | 1.000 | 0.721 |
| F words | 1.000 | 0.756 |
| Words | 1.000 | 0.680 |
| Uncued recalls | 1.000 | 0.932 |
| Cued recalls | 1.000 | 0.786 |
| Choice recalls | 1.000 | 0.724 |
| Month | 1.000 | 0.523 |
| Year | 1.000 | 0.800 |
| Week | 1.000 | 0.628 |
| City | 1.000 | 0.670 |
| Response time | 1.000 | 0.938 |
| Measure | 1.000 | 0.544 |

Extraction method: principal component analysis.

**Table A3.** Total explained variance from the distribution of DigMoCA variables into seven factors.

| | **Initial Eigenvalues** | | | **SSL after Extraction** | | | **SSL after Rotation** | | |
|---|---|---|---|---|---|---|---|---|---|
| **C** | **Total** | **% Var** | **% C** | **Total** | **% Var** | **% C** | **Total** | **% Var** | **% C** |
| 1 | 5.312 | 27.959 | 27.959 | 5.312 | 27.959 | 27.959 | 3.141 | 16.530 | 16.530 |
| 2 | 1.953 | 10.280 | 38.239 | 1.953 | 10.280 | 38.239 | 2.695 | 14.182 | 30.713 |
| 3 | 1.696 | 8.925 | 47.165 | 1.696 | 8.925 | 47.165 | 2.287 | 12.037 | 42.750 |
| 4 | 1.475 | 7.763 | 54.928 | 1.475 | 7.763 | 54.928 | 1.811 | 9.534 | 52.284 |
| 5 | 1.374 | 7.230 | 62.157 | 1.374 | 7.230 | 62.157 | 1.403 | 7.386 | 59.670 |
| 6 | 1.179 | 6.203 | 68.361 | 1.179 | 6.203 | 68.361 | 1.379 | 7.260 | 66.930 |
| 7 | 1.019 | 5.365 | 73.726 | 1.019 | 5.365 | 73.726 | 1.291 | 6.796 | 73.726 |
| 8 | 0.930 | 4.893 | 78.619 | | | | | | |
| 9 | 0.743 | 3.908 | 82.527 | | | | | | |
| 10 | 0.705 | 3.710 | 86.237 | | | | | | |
| 11 | 0.585 | 3.080 | 89.317 | | | | | | |
| 12 | 0.528 | 2.777 | 92.093 | | | | | | |
| 13 | 0.391 | 2.055 | 94.149 | | | | | | |
| 14 | 0.335 | 1.765 | 95.913 | | | | | | |
| 15 | 0.300 | 1.581 | 97.495 | | | | | | |
| 16 | 0.237 | 1.245 | 98.740 | | | | | | |
| 17 | 0.170 | 0.894 | 99.633 | | | | | | |
| 18 | 0.052 | 0.276 | 99.909 | | | | | | |
| 19 | 0.017 | 0.091 | 100.000 | | | | | | |

Extraction method: principal component analysis. SSL = sum of squared loadings; C = component; % Var = % variance; % C = % cumulative.

**Table A4.** Rotated component matrix.

| Variable | Component | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Calculations | 0.939 | | | | | | |
| Substractions | 0.916 | | | | | | |
| Words | 0.642 | | | | | | |
| F words | 0.600 | | | | | | |
| Letter mistakes | | −0.723 | | | | | |
| Letter | | 0.711 | | | | | |
| Second sentence | | 0.666 | | | | | |
| Week | | 0.630 | | | | | |
| Response time mean | | | −0.925 | | | | |
| Uncued recalls | | | 0.900 | | | | |
| First sentence | | | 0.447 | | | | |
| Backward numbers | | | | 0.856 | | | |
| Forward numbers | | | | 0.617 | | | |
| Month | | | | 0.569 | | | |
| Choice recalls | | | | | 0.771 | | |
| Measure | | | | | −0.657 | | |
| Year | | | | | | 0.869 | |
| City | | | | | | | 0.760 |
| Cued recalls | | | | | | | −0.622 |

Extraction method: principal component analysis. Rotation method: Varimax with Kaiser normalization. Rotation converged in nine iterations.

## References


1. Mathews, A.; MacLeod, C. Cognitive Vulnerability to Emotional Disorders. *Annu. Rev. Clin. Psychol.* **2005**, *1*, 167–195. [CrossRef] [PubMed]
2. Gotlib, I.H.; Joormann, J. Cognition and depression: Current status and future directions. *Annu. Rev. Clin. Psychol.* **2010**, *6*, 285–312. [CrossRef] [PubMed]
3. Ma, L. Depression, Anxiety, and Apathy in Mild Cognitive Impairment: Current Perspectives. *Front. Aging Neurosci.* **2020**, *12*, 9. [CrossRef] [PubMed]
4. Force, D.T. *Diagnostic and Statistical Manual of Mental Disorders*; American Psychiatric Association: Washington, DC, USA, 2013. [CrossRef]
5. Byers, A.L.; Yaffe, K. Depression and risk of developing dementia. *Nat. Rev. Neurol.* **2011**, *7*, 323–331. [CrossRef] [PubMed]
6. Blair, M.; Coleman, K.; Jesso, S.; Desbeaumes Jodoin, V.; Smolewska, K.; Warriner, E.; Finger, E.; Pasternak, S.H. Depressive Symptoms Negatively Impact Montreal Cognitive Assessment Performance: A Memory Clinic Experience. *Can. J. Neurol. Sci./J. Can. Des. Sci. Neurol.* **2016**, *43*, 513–517. [CrossRef] [PubMed]
7. Sekhon, S.; Patel, J.; Sapra, A. *Late-Life Depression*; StatPearls Publishing: Treasure Island, FL, USA, 2023.
8. Invernizzi, S.; Simoes Loureiro, I.; Kandana Arachchige, K.G.; Lefebvre, L. Late-Life Depression, Cognitive Impairment, and Relationship with Alzheimer's Disease. *Dement. Geriatr. Cogn. Disord.* **2021**, *50*, 414–424. [CrossRef] [PubMed]
9. John, A.; Patel, U.; Rusted, J.; Richards, M.; Gaysina, D. Affective problems and decline in cognitive state in older adults: A systematic review and meta-analysis. *Psychol. Med.* **2019**, *49*, 353–365. [CrossRef] [PubMed]
10. Perini, G.; Cotta-Ramusino, M.; Sinforiani, E.; Bernini, S.; Petrachi, R.; Costa, A. Cognitive impairment in depression: Recent advances and novel treatments. *Neuropsychiatr. Dis. Treat.* **2019**, *15*, 1249–1258. [CrossRef] [PubMed]
11. McIntyre, R.S.; Xiao, H.X.; Syeda, K.; Vinberg, M.; Carvalho, A.F.; Mansur, R.B.; Maruschak, N.; Cha, D.S. The Prevalence, Measurement, and Treatment of the Cognitive Dimension/Domain in Major Depressive Disorder. *CNS Drugs* **2015**, *29*, 577–589. [CrossRef]
12. Millan, M.J.; Agid, Y.; Brüne, M.; Bullmore, E.T.; Carter, C.S.; Clayton, N.S.; Connor, R.; Davis, S.; Deakin, B.; DeRubeis, R.J.; et al. Cognitive dysfunction in psychiatric disorders: Characteristics, causes and the quest for improved therapy. *Nat. Rev. Drug Discov.* **2012**, *11*, 141–168. [CrossRef]
13. Chen, L.; Zhen, W.; Peng, D. Research on digital tool in cognitive assessment: A bibliometric analysis. *Front. Psychiatry* **2023**, *14*, 1227261. [CrossRef] [PubMed]
14. Koo, B.M.; Vizer, L.M. Mobile Technology for Cognitive Assessment of Older Adults: A Scoping Review. *Innov. Aging* **2019**, *3*, igy038. [CrossRef] [PubMed]
15. Otero-González, I.; Pacheco-Lorenzo, M.R.; Fernández-Iglesias, M.J.; Anido-Rifón, L.E. Conversational agents for depression screening: A systematic review. *Int. J. Med. Inform.* **2024**, *181*, 105272. [CrossRef] [PubMed]

16. Pacheco-Lorenzo, M.; Fernández-Iglesias, M.J.; Valladares-Rodriguez, S.; Anido-Rifón, L.E. Implementing scripted conversations by means of smart assistants. *Softw. Pract. Exp.* **2023**, *53*, 1271–1283. [CrossRef]
17. Valladares-Rodríguez, S.; Fernández-Iglesias, M.J.; Anido-Rifón, L.E.; Pacheco-Lorenzo, M. Evaluation of the Predictive Ability and User Acceptance of Panoramix 2.0, an AI-Based E-Health Tool for the Detection of Cognitive Impairment. *Electronics* **2022**, *11*, 3424. [CrossRef]
18. Pereiro, A.X.; Ramos-Lema, S.; Lojo-Seoane, C.; Guàrdia-Olmos, J.; Facal-Mayo, D.; Juncos-Rabadán, O. Normative data for the Montreal Cognitive Assessment (MOCA) in a Spanish sample of community-dweller adults. *Eur. Geriatr. Med.* **2017**, *8*, 240–244. [CrossRef]
19. Islam, N.; Hashem, R.; Gad, M.; Brown, A.; Levis, B.; Renoux, C.; Thombs, B.D.; McInnes, M.D. Accuracy of the Montreal Cognitive Assessment tool for detecting mild cognitive impairment: A systematic review and meta-analysis. *Alzheimers Dement.* **2023**, *19*, 3235–3243. [CrossRef] [PubMed]
20. Sheikh, J.I.; Yesavage, J.A. Geriatric Depression Scale (GDS). Recent Evidence and Development of a Shorter Version. In *Clinical Gerontology*; Taylor & Francis Group: Abingdon, UK, 1986.
21. Graf, C. The Lawton instrumental activities of daily living scale. *Am. J. Nurs.* **2008**, *108*, 52–62. [CrossRef] [PubMed]
22. Ozer, U.G.; Orhan, F.O.; Celik, M.; Ekerbicer, H.C.; Karaaslan, M.F. Use of clock drawing test as a screening tool for cognitive status evaluation in middle-aged patients with depressive disorder. *Psychiatry Clin. Psychopharmacol.* **2012**, *22*, 332–339. [CrossRef]
23. Cacho, J.; García-García, R.; Arcaya, J.; Vicente, J.; Lantada, N. Una propuesta de aplicación y puntuación del test del reloj en la enfermedad de Alzheimer Una propuesta de aplicación y puntuación del test del reloj en la enfermedad de Alzheimer. *Rev. Neurol.* **1999**, *28*, 648–655. [CrossRef]
24. Yazici, B.; Yolacan, S. A comparison of various tests of normality. *J. Stat. Comput. Simul.* **2007**, *77*, 175–183. [CrossRef]
25. McKight, P.E.; Najab, J. Kruskal-Wallis Test. In *The Corsini Encyclopedia of Psychology*; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2010. [CrossRef]
26. McKnight, P.E.; Najab, J. Mann-Whitney U Test. In *The Corsini Encyclopedia of Psychology*; John Wiley & Sons, Ltd.: Hoboken, NJ, USA, 2010. [CrossRef]
27. Greenacre, M.; Groenen, P.J.F.; Hastie, T.; D'Enza, A.I.; Markos, A.; Tuzhilina, E. Principal component analysis. *Nat. Rev. Methods Prim.* **2022**, *2*, 100. [CrossRef]
28. Ali Abd Al-Hameed, K. Spearman's correlation coefficient in statistical analysis. *Int. J. Nonlinear Anal. Appl.* **2022**, *13*, 3249–3255. [CrossRef]
29. Meinert, S.; Nowack, N.; Grotegerd, D.; Repple, J.; Winter, N.R.; Abheiden, I.; Enneking, V.; Lemke, H.; Waltemate, L.; Stein, F.; et al. Association of brain white matter microstructure with cognitive performance in major depressive disorder and healthy controls: A diffusion-tensor imaging study. *Mol. Psychiatry* **2022**, *27*, 1103–1110. [CrossRef] [PubMed]
30. Lee, C.H.; Kim, D.H.; Moon, Y.S. Differential associations between depression and cognitive function in MCI and AD: A cross-sectional study. *Int. Psychogeriatr.* **2019**, *31*, 1151–1158. [CrossRef] [PubMed]
31. Enache, D.; Almkvist, O.; Gregoric Kramberger, M.; Jelic, V.; Eriksdotter, M.; Lebedeva, A.; Göthe, F.; Winblad, B.; Aarsland, D. 1621—Depressive symptoms and cognitive functioning in elderly. *Eur. Psychiatry* **2013**, *28*, 1. [CrossRef]
32. Herrmann, N.; Kidron, D.; Shulman, K.I.; Kaplan, E.; Binns, M.; Leach, L.; Freedman, M. Clock Tests in Depression, Alzheimer's Disease, and Elderly Controls. *Int. J. Psychiatry Med.* **1998**, *28*, 437–447. [CrossRef] [PubMed]
33. Snyder, H.R. Major depressive disorder is associated with broad impairments on neuropsychological measures of executive function: A meta-analysis and review. *Psychol. Bull.* **2013**, *139*, 81–132. [CrossRef]
34. Ramos-Henderson, M.; Ledezma-Dámes, A.; Kay, A.P.M.G.M.; López, N. Executive functions and functional impairment in Latin seniors suffering from depression. *Aging Neuropsychol. Cogn.* **2021**, *28*, 543–558. [CrossRef] [PubMed]
35. Klojčnik, M.; Kavcic, V.; Vukman, K.B. Relationship of Depression with Executive Functions and Visuospatial Memory in Elderly. *Int. J. Aging Hum. Dev.* **2017**, *85*, 490–503. [CrossRef] [PubMed]
36. Camfield, D.A.; Fontana, R.; Wesnes, K.A.; Mills, J.; Croft, R.J. Effects of aging and depression on mnemonic discrimination ability. *Aging Neuropsychol. Cogn.* **2018**, *25*, 464–483. [CrossRef] [PubMed]
37. Yatawara, C.; Lim, L.; Chander, R.; Zhou, J.; Kandiah, N. Depressive symptoms influence global cognitive impairment indirectly by reducing memory and executive function in patients with mild cognitive impairment. *J. Neurol. Neurosurg. Psychiatry* **2016**, *87*, 1375–1383. [CrossRef] [PubMed]
38. Brunet, J.; Hudon, C.; Macoir, J.; Belleville, S.; Rousseau, F.; Bouchard, R.W.; Verret, L.; Chertkow, H.; Chayer, C.; Kergoat, M.J.; et al. The Relation between Depressive Symptoms and Semantic Memory in Amnestic Mild Cognitive Impairment and in Late-Life Depression. *J. Int. Neuropsychol. Soc.* **2011**, *17*, 865–874. [CrossRef] [PubMed]
39. Yoon, S.; Shin, C.; Han, C. Depression and Cognitive Function in Mild Cognitive Impairment: A 1-Year Follow-Up Study. *J. Geriatr. Psychiatry Neurol.* **2017**, *30*, 280–288. [CrossRef] [PubMed]
40. Lang, M.; Rosselli, M.; Greig, M.T.; Torres, V.L.; Vélez-Uribe, I.; Arruda, F.; Barker, W.W.; Garcia, P.; Loewenstein, D.A.; Curiel, R.E.; et al. Depression and the Diagnosis of MCI in a Culturally Diverse Sample in the United States. *Arch. Clin. Neuropsychol.* **2019**, *36*, 214–230. [CrossRef] [PubMed]
41. Rajtar-Zembaty, A.; Rajtar-Zembaty, J.; Sałakowski, A.; Starowicz-Filip, A.; Skalska, A. Executive functions and working memory in motor control: Does the type of MCI matter? *Appl. Neuropsychol. Adult* **2020**, *27*, 580–588. [CrossRef] [PubMed]

42. Beheydt, L.L.; Schrijvers, D.; Docx, L.; Bouckaert, F.; Hulstijn, W.; Sabbe, B. Psychomotor Retardation in Elderly Untreated Depressed Patients. *Front. Psychiatry* **2015**, *5*, 196. [CrossRef]
43. Zacková, L.; Jáni, M.; Brázdil, M.; Nikolova, Y.S.; Marečková, K. Cognitive impairment and depression: Meta-analysis of structural magnetic resonance imaging studies. *NeuroImage Clin.* **2021**, *32*, 102830. [CrossRef]