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# Do sex and handedness influence general cognition and financial capacity in patients with aMCI and healthy older adults? Emphasis on women's performance

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**Abstract**

**Objectives:** The effects of sex and handedness on financial capacity performance remain unexplored both in healthy older adults and in patients with amnestic mild cognitive impairment (aMCI).

**Methods:** The aim of this study was to study the effect of the above factors (sex, handedness, and health condition), following a factorial experimental design; hence, eight groups (each with ten individuals) with similar demographic characteristics (age and education level) were formed consisting of right/left-handed, women/men and healthy/not healthy (with a diagnosis of aMCI) older adults. Mini-Mental State Examination (MMSE) was administered as a measure of general cognitive ability, and Legal Capacity for Property Law Transactions Assessment Scale (LCPLTAS) was used as an indicator of financial capacity; moreover, GDS-15 was used to assess depressive symptomatology. Self-reports of hand preference were also included.

**Results:** Although as expected healthy men and women regardless of their handedness outperformed aMCI patients on MMSE and LCPLTAS, performance on cash transactions, bank statement management, bill payment, financial decision making, and knowledge of personal assets from LCPLTAS is significantly higher for right-handed aMCI women compared with left-handed aMCI women.

**Conclusions:** Future research should further elucidate the reasons for this left-handed female patient with aMCI profile in larger groups of patients. This is an exploratory study, and the small sample size limits the strength of conclusions; further studies on this topic are needed.

**Keywords:** sex, handedness, financial capacity, healthy, aMCI

## Introduction

Studies examining the association of handedness with cognitive function so far have shown inconsistent results, especially due to the different conceptualizations of handedness (eg, preference to use one hand over the other or the ability-skill to perform tasks better more efficiently with one hand).[1] Based on a recent meta-analysis when handedness is assessed as hand preference and the classification is according to direction (as left-handers vs right-handers), no differences in general cognitive ability are reported between handedness groups.[2] Nevertheless, researchers do not use the same neuropsychological tests and do not examine the same cognitive domains.[2]

More specifically, regarding mathematical/arithmetic abilities, left-handed individuals (less than 14 years of age) have been found to perform lower in tests in mathematics compared with their right-handed counterparts, and this also holds true about younger left-and-mixed-handed children (ages ranging from 4 to 5 years), who score lower in mathematical/arithmetic tasks than right-handed children.[2] Although deficiencies relating to numbers, quantities and calculations are part of financial capacity along with other relevant cognitive domains, such as conceptual knowledge and decision making[3] and have been found to lie at the heart of financial capacity deficits in Mild Cognitive Impairment (MCI),[4] still a major gap in scientific literature exists when financial capacity, which is a complex cognitive capacity that has many arithmetic/mathematical facets, is considered.

Given that there is no data collection for children, young adults, older adults, and older patients with neurocognitive disorders based on sex and handedness regarding financial capacity, the aim of this study was to examine if and how these two individuals (mainly genetically determined) characteristics can influence a form of complex cognitive ability/capacity, such as financial capacity. A

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IRB statement: This study was conducted in accordance with the Declaration of Helsinki. Approval was obtained by the Ethics Committee of Aristotle University of Thessaloniki, School of Medicine.

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hypothesis tested for the first time here is whether left-handed older adults demonstrate more deficits in overall financial capacity as well as in different domains that consist financial capacity (including arithmetic skills, which are considered an integral part of financial capacity, and which have been found by other researchers to be impaired in left-handed).[2] In addition to the above, memory impairment which is characteristic of amnestic mild cognitive impairment (aMCI) is very often accompanied by difficulties in executive functioning in these patients. What is of interest here is that executive functioning components (eg, information updating, shifting, and inhibition) have been found to be influenced by handedness in the group of upper-middle-aged people,[5] but executive functions are also part of financial capacity.[4] Therefore, sex and handedness were also examined through the prism of neurocognitive diagnosis (aMCI).

## Materials and methods

Participants consist of eighty older, equally distributed (balanced design) among the eight combinations of the levels of the factors sex(male/female), handedness(left/right), and health condition (healthy/not-healthy aMCI). Although there is a greater male tendency toward left-handedness,[6] in this study we adopted a balanced factorial experimental design, wherein the participants in each group have similar demographic characteristics (age and education level, all with prior experience with financial matters, and all middle socioeconomic status).[4] Patients' diagnosis was reached after a full neurological, neuropsychological, physical, and laboratory assessment. The data coming from each patient were gathered and assessed by the members of the team (at the memory and dementia clinic of the G. Papanikolaou General

**Table 1**

**Sample means, standard deviations (std), and quartiles (25, 50 and 75), for general cognition, financial capacity performance (the seven domains and total score), age, and education (in years), for each of the eight groups.**

| | | | | | LCPLTAS (subscales) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Age | Education | MMSE* | Basic monetary skills | Cash Trans.* | Bank statement manag.* | Bill payment* | Financial conceptual knowledge* | Financial decision making* | Knowledge of personal assets* | LCPLTAS (total)* |
| Right-handed healthy men | Mean | | 70.80 | 9.40 | 28.50 | 14.00 | 8.00 | 7.90 | 8.00 | 32.00 | 114.00 | 28.00 | 211.90 |
| | Std | | 9.35 | 2.99 | 0.53 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 |
| | | 25 | 58.75 | 6.00 | 28.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 50 | 74.00 | 9.00 | 28.50 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 75 | 78.25 | 12.00 | 29.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| Right-handed healthy women | Mean | | 67.20 | 9.00 | 28.80 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 113.90 | 28.00 | 211.90 |
| | Std | | 5.39 | 4.27 | 0.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.32 | 0.00 | 0.32 |
| | | 25 | 62.75 | 5.75 | 28.75 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 50 | 66.50 | 9.00 | 29.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 75 | 72.25 | 12.00 | 29.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| Left-handed healthy men | Mean | | 69.10 | 11.20 | 28.90 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | Std | | 5.15 | 3.65 | 1.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| | | 25 | 65.75 | 8.25 | 28.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 50 | 69.50 | 12.00 | 29.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 75 | 71.25 | 14.50 | 30.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| Left-handed healthy women | Mean | | 67.50 | 10.30 | 28.30 | 14.00 | 8.00 | 7.90 | 8.00 | 32.00 | 113.90 | 28.00 | 211.80 |
| | Std | | 8.30 | 5.08 | 1.34 | 0.00 | 0.00 | 0.32 | 0.00 | 0.00 | 0.32 | 0.00 | 0.42 |
| | | 25 | 61.50 | 6.00 | 27.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 211.75 |
| | | 50 | 65.00 | 8.50 | 28.50 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| | | 75 | 75.75 | 16.50 | 29.25 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 212.00 |
| Right-handed aMCI men | Mean | | 73.50 | 8.40 | 26.10 | 13.90 | 7.90 | 7.80 | 7.80 | 32.00 | 112.90 | 27.80 | 210.10 |
| | Std | | 10.94 | 1.26 | 1.10 | 0.32 | 0.32 | 0.42 | 0.42 | 0.00 | 0.99 | 0.42 | 0.99 |
| | | 25 | 65.75 | 8.25 | 25.75 | 14.00 | 8.00 | 7.75 | 7.75 | 32.00 | 112.00 | 27.75 | 209.00 |
| | | 50 | 68.00 | 9.00 | 26.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 112.50 | 28.00 | 210.00 |
| | | 75 | 86.75 | 9.00 | 26.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 211.00 |
| Right-handed aMCI women | Mean | | 65.00 | 11.40 | 26.20 | 14.00 | 7.78 | 7.89 | 7.89 | 30.33 | 113.11 | 27.78 | 208.78 |
| | Std | | 0.00 | 1.58 | 1.14 | 0.00 | 0.44 | 0.33 | 0.33 | 1.58 | 1.05 | 0.44 | 2.11 |
| | | 25 | 65.00 | 9.75 | 25.75 | 14.00 | 7.50 | 8.00 | 8.00 | 29.00 | 112.00 | 27.50 | 207.00 |
| | | 50 | 65.00 | 12.00 | 26.00 | 14.00 | 8.00 | 8.00 | 8.00 | 29.00 | 114.00 | 28.00 | 209.00 |
| | | 75 | 65.00 | 13.00 | 26.25 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 210.50 |
| Left-handed aMCI men | Mean | | 73.50 | 8.90 | 25.60 | 13.80 | 7.90 | 7.70 | 7.70 | 30.80 | 112.90 | 27.60 | 208.40 |
| | Std | | 10.61 | 3.48 | 0.52 | 0.42 | 0.32 | 0.48 | 0.48 | 1.55 | 1.20 | 0.52 | 2.67 |
| | | 25 | 66.00 | 6.00 | 25.00 | 13.75 | 8.00 | 7.00 | 7.00 | 29.00 | 112.00 | 27.00 | 205.75 |
| | | 50 | 68.00 | 7.00 | 26.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 113.00 | 28.00 | 208.50 |
| | | 75 | 79.25 | 12.00 | 26.00 | 14.00 | 8.00 | 8.00 | 8.00 | 32.00 | 114.00 | 28.00 | 211.25 |
| Left-handed aMCI women | Mean | | 69.10 | 9.20 | 26.10 | 13.70 | 7.10 | 7.10 | 7.10 | 30.50 | 110.30 | 26.70 | 202.50 |
| | Std | | 11.38 | 4.10 | 0.57 | 0.48 | 0.57 | 0.57 | 0.57 | 1.08 | 1.49 | 0.82 | 3.78 |
| | | 25 | 65.00 | 6.00 | 26.00 | 13.00 | 7.00 | 7.00 | 7.00 | 29.75 | 109.00 | 26.00 | 199.75 |
| | | 50 | 65.00 | 7.50 | 26.00 | 14.00 | 7.00 | 7.00 | 7.00 | 30.50 | 110.00 | 26.50 | 201.00 |
| | | 75 | 72.00 | 13.00 | 26.25 | 14.00 | 7.25 | 7.25 | 7.25 | 31.25 | 111.25 | 27.25 | 205.25 |

* Statistically significant difference across the 8 groups, using Kruskal-Wallis test ($P<0.001$)

Hospital, which was supervised by a specialized neuropsychiatrist—Magda Tsolaki). aMCI diagnosis was made according to the criteria of Petersen and more specifically: subjective memory complaint by the individual or an informant (usually corroborated by an informant), preserved general cognitive function, objective memory impairment below 1.0 standard deviation (SD) of age, sex, and education matched norms, and independent performance of daily life activities-intact functional activities.[7]

Participants completed a demographics questionnaire with an additional question about handedness ("Never left-handed", "Always have been right-handed" or "Never right-handed," "Always have been left-handed"). Exclusion criteria as in previous protocols referred to existence of other psychiatric/neurological or other medical disorder (eg, diagnosis of depression or depressive symptomatology present at examination), existence of vascular pathology, age below 65, visual/auditory deficits not corrected.[4] Written informed consent was obtained by all participants and the study was approved by the Ethics Committee of Aristotle University of Thessaloniki, School of Medicine (protocol code 2 and date of approval: March 27, 2013), following the declaration of Helsinki.

Financial capacity is not just numerical capacity but refers also to the capacity to judge and assess situations and make decisions. In this sample, financial capacity was measured with the Legal Capacity for Property Law Transactions Assessment Scale (LCPLTAS), a scale that has a good reliability as assessed by means of internal consistency using Cronbach's alpha coefficient ($\alpha = 0.93$).[4] LCPLTAS measures in its full form seven domains: 1) basic monetary skills, 2) cash transactions, 3) bank statement management, 4) bill payment, 5) financial conceptual knowledge, 6) financial decision making, and 7) knowledge of personal assets.[8,9] General cognition was assessed with the widely used (in Greece) Mini-Mental State Examination (MMSE) total score ($\alpha = 0.85$).[10] Depressive symptomatology was assessed with the Geriatric Depression Scale (GDS-15) ($\alpha = 0.94$), an internationally used instrument for the assessment of geriatric depression.[11]

Statistical analysis starts with an initial descriptive examination of the variables and followed by testing hypotheses, based on nonparametric approaches. Thus, we used Kruskal-Wallis tests[12,13] along with analysis of variance techniques based on bootstrap, for assessing the effect of independent variables on the two outcomes: MMSE and LCPLTAS (for total score and for each of the seven domains). Cluster and discriminant analysis techniques provide us with useful perspective of our dataset; the analysis was performed by using SPSS 29.0.[14]

## Results

The descriptive statistics (sample means, standard deviations, and quartiles) of the variables included in our study, and for each experimental group separately, can be found in Table 1 (to mention that the LCPLTAS values are missing for one participant). As can be deduced by the Kruskal-Wallis test (Table 1), for most of the variables, we had statistically significant differences ($P<0.001$), across the eight experimental groups (note also the zero variability for many of the seven domains of LCPLTAS, in healthy groups). Moreover, Table 2 refers to the multiple (simultaneously) pairwise comparisons, using a Bonferroni adjustment to the Kruskal-Wallis tests (each cell includes the variables for which the difference for the corresponding pair, determined by the column and row of the table, is statistically

**Table 2**

**Multiple pairwise comparisons using the Kruskal-Wallis with Bonferroni correction, at 0.05 level of significance (each cell includes the variables for which the difference for the corresponding pair, determined by the column and row of the table, is statistically significant).**

| | Right-handed healthy men | Right-handed healthy women | Left-handed healthy men | Left-handed healthy women | Right-handed aMCI men | Right-handed aMCI women | Left-handed aMCI men |
|---|---|---|---|---|---|---|---|
| Right-handed healthy men | | | | | | | |
| Right-handed healthy women | — | | | | | | |
| Left-handed healthy men | — | — | | | | | |
| Left-handed healthy women | — | — | — | | | | |
| Right-handed aMCI men | MMSE | MMSE | MMSE | — | | | |
| Right-handed aMCI women | MMSE<br>LCPLTAS | MMSE<br>LCPLTAS | MMSE<br>LCPLTAS | — | — | | |
| Left-handed aMCI men | MMSE<br>LCPLTAS | MMSE<br>LCPLTAS | MMSE<br>LCPLTAS | MMSE | — | — | |
| Left-handed aMCI women | MMSE<br>CASH<br>BANK<br>BILL<br>FINAN<br>DECIS<br>KNOW<br>LCPLTAS | MMSE<br>CASH<br>BANK<br>BILL<br>DECIS<br>KNOW<br>LCPLTAS | MMSE<br>CASH<br>BANK<br>BILL<br>FINAN<br>DECIS<br>KNOW<br>LCPLTAS | CASH<br>BANK<br>BILL<br>FINAN<br>DECIS<br>KNOW<br>LCPLTAS | CASH<br>BANK<br>BILL<br>FINAN<br>KNOW | CASH<br>BANK<br>BILL<br>DECIS<br>KNOW | CASH |

BANK, bank statement management; BILL, bill payment; CASH, cash transactions; DECIS, financial decision making; FINAN, financial conceptual knowledge; KNOW, knowledge of personal assets.

**Table 3**

**ANOVA (bootstrap) with MMSE as dependent variable.**

| Parameter | B | Bootstrap* | | | | |
|---|---|---|---|---|---|---|
| | | Bias | Std. error | Sig. (2-tailed) | 95% confidence interval | |
| | | | | | Lower | Upper |
| Intercept | 28.021 | −0.069 | 0.955 | 0.002 | 26.015 | 29.920 |
| Age | 0.002 | 0.001 | 0.012 | 0.840 | −0.020 | 0.025 |
| Education (in years) | 0.033 | 0.000 | 0.030 | 0.295 | −0.025 | 0.096 |
| Sex (women) | 0.322 | 0.010 | 0.213 | 0.138 | −0.093 | 0.734 |
| Health (aMCI) | −2.374 | 0.014 | 0.400 | 0.002 | −3.020 | −1.530 |
| Hand (Left) | 0.345 | 0.014 | 0.404 | 0.443 | −0.434 | 1.142 |
| Sex (women)* Health (aMCI) | −0.299 | −0.008 | 0.636 | 0.691 | −1.473 | 1.011 |
| Sex (women)* Hand (Left) | −0.889 | −0.004 | 0.581 | 0.130 | −2.012 | 0.168 |
| Health (aMCI)*Hand (Left) | −0.862 | −0.020 | 0.536 | 0.120 | −1.899 | 0.195 |
| Sex (women)* Health (aMCI)* Hand (Left) | 1.367 | 0.009 | 0.870 | 0.124 | −0.370 | 3.031 |

* 500 iterations of sample size n = 80 ($R^2$ = 0.705).

significant, at 0.05 level of significance). According to this, left-handed aMCI women had a quite different profile, since for most of the variables and pairwise comparisons, the differences were statistically significant; for example, for the pair left-handed aMCI women and right-handed healthy men, all the variables, with the exception of "basic monetary skills," were significantly different (this is also the case for the pair left-handed aMCI women and left-handed healthy men—the "basic monetary skills" was not significantly different for any pair). Furthermore, five variables ("cash transactions," "bank statement management," "bill payment," "financial decision making," and "knowledge of personal assets") showed a significant difference between left-handed aMCI women and right-handed aMCI women. Overall, there was no other significant difference, within the same sex and health condition, ie, between "left vs right-handed healthy men," "left vs right-handed healthy women," and "left vs right-handed aMCI men." Furthermore, within the same handedness and health condition (ie, between "right-handed healthy men vs women," "left-handed healthy men vs women," "right-handed aMCI men vs women," and "left-handed aMCI men vs women"), the only significant difference was between left-handed aMCI women and left-handed aMCI men, in "cash transactions" (men had higher scores on average). As was probably expected, the most distinguishable profiles were found

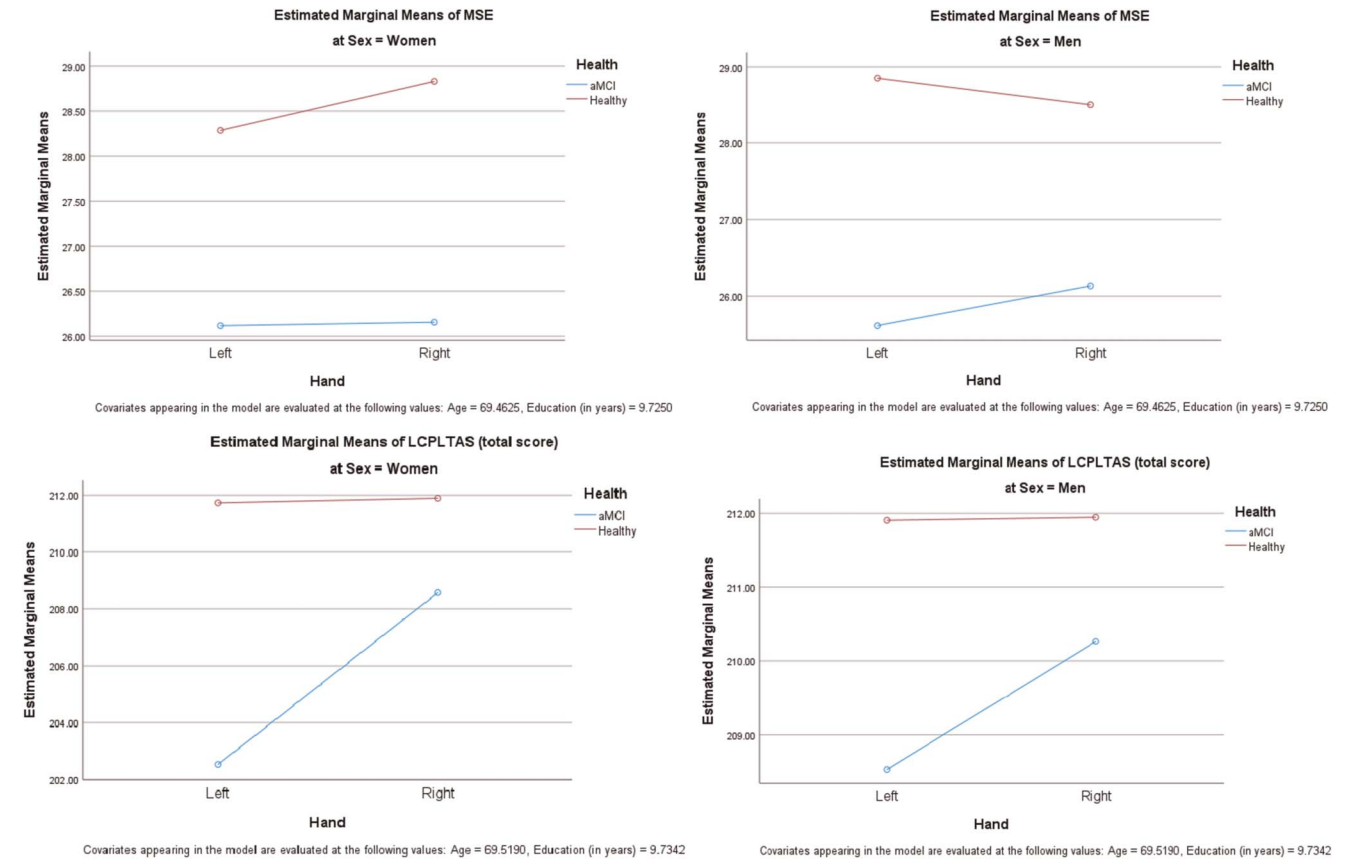


**Figure 1.** Marginal means, across sex, handedness, and health condition.

**Table 4**

**ANOVA (bootstrap) with LCPLTAS (total score) as dependent variable.**

| Parameter | B | Bootstrap* | | | | |
|---|---|---|---|---|---|---|
| | | Bias | Std. error | Sig. (2-tailed) | 95% confidence interval | |
| | | | | | Lower | Upper |
| Intercept | 212.887 | −0.034 | 2.698 | 0.002 | 207.285 | 218.348 |
| Age | −0.022 | <0.001 | 0.037 | 0.539 | −0.098 | 0.048 |
| Education (in years) | 0.057 | 0.005 | 0.082 | 0.493 | −0.088 | 0.229 |
| Sex (women) | −0.055 | −0.002 | 0.306 | 0.842 | −0.710 | 0.608 |
| Health (aMCI) | −1.685 | −0.023 | 0.398 | 0.002 | −2.445 | −0.872 |
| Hand (Left) | −0.039 | −0.013 | 0.303 | 0.876 | −0.811 | 0.479 |
| Sex (women)* Health (aMCI) | −1.637 | 0.013 | 0.920 | 0.100 | −3.665 | 0.108 |
| Sex (women)* Hand (Left) | −0.128 | 0.017 | 0.423 | 0.705 | −0.801 | 0.848 |
| Health (aMCI)*Hand (Left) | −1.689 | 0.117 | 1.019 | 0.118 | −3.602 | 0.651 |
| Sex (women)* Health (aMCI)* Hand (Left) | −4.192 | −0.129 | 1.817 | 0.048 | −7.542 | −0.244 |

* 500 iterations of sample size n = 80 ($R^2$ = 0.761).

within the same sex and handedness (ie, between "right-handed healthy vs aMCI men," "left-handed healthy vs aMCI men," "right-handed healthy vs aMCI women," and "left-handed healthy vs aMCI women"); specifically, in most of the cases, MMSE and LCPLTAS (total score) were different between healthy and patients. Generally, the most different profiles emerged between left-handed healthy women and left-handed aMCI women; it seems that left-handed aMCI women performed much worse than their healthy counterparts (ie, aMCI seems to affect much more the left-handed women than any other group).

To get a thorough insight into the effect of sex, handedness, and health condition on MMSE and financial capacity, also considering interaction effects (which cannot be addressed by the previous multiple pairwise comparisons), we performed a series of analysis of variance (ANOVA). The parameter estimates, when the dependent variable was MMSE, can be found in Table 3 (using bootstrap and 500 iterations of samples of size n=80). As can be seen, the only significant effect was that of health condition; specifically, aMCI had a negative effect (−2.374) on MMSE, which however was affected/mitigated by the existence of interaction effects. Although nonsignificant, interaction effects played a role, as can also be seen by the upper part of Figure 1; while the MMSE was increasing moving from left to right-handed healthy women (MMSE seemed to be constant for the aMCI group), the reverse happened for men. If the dependent variable was the LCPLTAS (total score), the health condition and the three-way interaction were the only significant effects (Table 4). Obviously, the largest negative effect was found for the left-handed women with aMCI (note also that the corresponding interaction equals −4.192).

Table 5 provides us with the parameter (beta) estimates, for each of the seven subscales of LCPLTAS separately. Note the significant negative three-way interaction for four subscales; for example, "financial decision making" was much worse for left-handed women with aMCI. Age had a significant negative effect on "basic monetary skills," whereas it had a positive effect on "financial conceptual knowledge," although nonsignificant.

The distinct profile of the left-handed women with aMCI was further supported by the results of cluster analysis. Cluster analysis techniques consider the classification of people into homogeneous groups/clusters, according to their responses to a set of variables.[15] Although we have already seen by the previous results that some experimental groups revealed a different profile, a worth answering question is, however, how many homogeneous groups/clusters of individuals existed in our data (since some of the experimental groups seemed to be quite similar). Hence, in this context (ignoring on which experimental group each of our individual belongs), we performed a two-step cluster analysis (distance measure: log-likelihood and BIC as clustering criterion) with sex, health condition, handedness, age, years of education, MMSE, and LCPLTAS (with all seven domains) being among the independent/grouping variables. This procedure

**Table 5**

**Parameter estimates (betas) from ANOVA (bootstrap), with the seven domains of LCPLTAS dependent variables.**

| Parameter* | Dependent variable | | | | | | |
|---|---|---|---|---|---|---|---|
| | Basic monetary skills | Cash transactions | Bank statement management | Bill payment | Financial conceptual knowledge | Financial decision making | Knowledge of personal assets |
| Intercept | 15.245 | 8.244 | 8.710 | 8.549 | 30.810 | 113.371 | 27.958 |
| Age | **−0.017*** | −0.005 | −0.012 | −0.009 | 0.016 | 0.007 | −0.002 |
| Education (in years) | −0.006 | 0.013 | 0.001 | 0.010 | 0.005 | 0.016 | 0.018 |
| Sex (women) | −0.063 | −0.013 | 0.059 | −0.029 | 0.060 | −0.069 | 0.001 |
| Health (aMCI) | −0.061 | −0.072 | −0.068 | −0.166 | −0.038 | **−1.103*** | −0.177 |
| Hand (Left) | −0.017 | −0.033 | 0.079 | −0.033 | 0.018 | −0.017 | −0.036 |
| Sex (women) · Health (aMCI) | 0.041 | −0.197 | −0.071 | 0.008 | **−1.607*** | 0.287 | −0.098 |
| Sex (women) · Hand (Left) | 0.030 | 0.017 | −0.176 | 0.023 | −0.030 | −0.006 | 0.013 |
| Health (aMCI) · Hand (Left) | −0.080 | 0.026 | −0.179 | −0.072 | **−1.220*** | 0.009 | −0.173 |
| Sex (women) · Health (aMCI) · Hand (Left) | **−0.180*** | −0.634 | −0.462 | **−0.645*** | 1.346 | **−2.787*** | **−0.829*** |
| $R^2$ | .411 | .544 | .440 | .516 | .445 | .675 | .555 |

* $P<.05$ (bootstrap was based on 500 iterations of sample size n = 80).

**Table 6**

**Sample means and multiple pairwise comparisons (Kruskal-Wallis and chi-square tests for proportions, with Bonferroni correction), across clusters.**

| | Cluster | | | Non-sign.* |
|---|---|---|---|---|
| | 1 n=40 | 2 n=11 | 3 n=28 | |
| Age | 68.25 | 75.91 | 68.65 | All |
| Education (in years) | 10.21 | 7.64 | 9.98 | All |
| Sex (prop. of males) | 50% | 27.3% | 60.7% | All |
| Health (prop. of healthy) | 100% | 0% | 0% | 2–3 |
| Handedness (prop. of right-handed) | 50% | 9.1% | 64.3% | 1–3 |
| MMSE | 25.96 | 26.00 | 28.63 | 1–2 |
| Basic monetary skills | 14.00 | 13.45 | 14.00 | 1–3 |
| Cash transactions | 7.89 | 7.09 | 8.00 | 1–3 |
| Bank statement management | 7.89 | 6.91 | 7.95 | 1–3 |
| Bill payment | 7.89 | 6.91 | 8.00 | 1–3 |
| Financial conceptual knowledge | 30.93 | 30.91 | 32.00 | 1–2 |
| Financial decision making | 112.93 | 110.64 | 113.95 | — |
| Knowledge of personal assets | 27.75 | 26.73 | 28.00 | 1–3 |
| LCPLTAS (total score) | 209.29 | 202.64 | 211.90 | — |

* Pairs with non-significant difference.

suggested the existence of three distinct clusters(based on the built-in, two-step procedure of SPSS): The first cluster was consisted of the 40 healthy participants, and the second cluster had 11 participants, mainly left-handed women with aMCI (the remaining 28 participants formed the third cluster).To be more precise, 8 of the 11 participants of the second cluster came from the left-handed aMCI women group, and the others were aMCI men with 98 (right-handed), 92 (left-handed), and 80 (left-handed) years. The differences of the seven domains of LCPLTAS (and the total score itself) and MMSE were all statistically significant ($P<0.001$), across the three clusters (Table 6).

To further examine the role of our variables in the formulation of each cluster, and investigating the main distinct characteristics of each cluster, simultaneously considering the role of all variables, we contacted a descriptive discriminant analysis,[16] using the seven domains of LCPLTAS and MMSE as independent variables (Table 7). By doing so, two discriminant functions were statistically significant ($P<0.001$) and contributing to the classification of participants; 96.2% of the cases were correctly classified into the three clusters. The first function (which explains 82% of the variance) was mainly affected/characterized by the domains of LCPLTAS (excluding "financial conceptual knowledge" and "cash transactions"), whereas the second function by MMSE. The parallel discriminant ratio coefficients further supported the role of the above variables to the discriminant functions. Moreover, as can be seen by Figure 2, the two functions offered sufficient discrimination of the three clusters; it seems that cluster 1 and 3 mainly differed in MMSE, whereas what discriminate the second cluster by the other two clusters, were the values one the first function (ie, the scores on the domains of LCPLTAS).

## Discussion

Based on the above, biological sex and hand preference seem to play a special role when general cognition and financial capacity are examined in psychiatric settings and more specifically when the examinees are older adults with a diagnosis of mild neurocognitive disorder. What is of interest is that this study did reveal a strong relation between handedness and financial capacity performance, and all its subdomains, especially for the diagnostic group of female patients with aMCI. Although this finding does not support the hypothesized poorer cognitive performance of left-handed healthy women (in classic neuropsychological task such as immediate and delayed memory, attention, and verbal fluency) compared with healthy right-handed or ambidextrous healthy women,[1] it adds a new perspective to the ongoing debate of mathematical/arithmetic abilities and handedness by supporting that for the assessment of more complex and demanding activities such as financial capacity, handedness should be not neglected and should be examined along with other factors.

Thus, the idea of a sex effect for left-handed can be supported only for the group of women with aMCI. In addition to that, the present findings fail to support the other side of the literature that claims that left-handers are better in tasks that require mainly mathematic abilities and strong right-handers perform the worst in mathematical tasks.[17] It seems that financial capacity encompasses a broader range not only of mathematical tasks (eg, arithmetic and reasoning), but also of related verbal capacities and decision-making relating to conceptual knowledge as well as arithmetic skills, and therefore, the influence of handedness may not be so important compared with mood or literacy.[8,9]

It is interesting that this research adds to the controversial issue of the relationship between handedness and mathematical/arithmetic abilities, that no such evidence exists for a little investigated population that is older controls as well

**Table 7**

**Linear discriminant analysis based on the three-cluster solution, with MSE and the seven domains of LCPLTAS, as independent variables.**

| | Stand. canonical discriminant Funct. coef. | | Structure matrix | | Parallel discriminant ratio coefficient | |
|---|---|---|---|---|---|---|
| | Function | | Function | | Function | |
| | 1 | 2 | 1 | 2 | 1 | 2 |
| MSE | 0.05 | 0.98 | 0.27 | 0.84 | 0.01 | 0.82 |
| Basic monetary skills | 0.60 | −0.22 | 0.32 | −0.13 | 0.19 | 0.03 |
| Cash transactions | 0.03 | 0.25 | 0.37 | −0.02 | 0.01 | −0.01 |
| Bank statement management | 0.45 | −0.20 | 0.43 | −0.11 | 0.19 | 0.02 |
| Bill payment | 0.44 | −0.27 | 0.56 | −0.07 | 0.24 | 0.02 |
| Financial conceptual knowledge | −0.03 | 0.32 | 0.11 | 0.33 | 0.00 | 0.11 |
| Financial decision making | 0.47 | 0.17 | 0.39 | 0.21 | 0.18 | 0.03 |
| Knowledge of personal assets | 0.47 | −0.43 | 0.36 | 0.06 | 0.17 | −0.03 |
| %Variance | 82% | 18% | | | | |

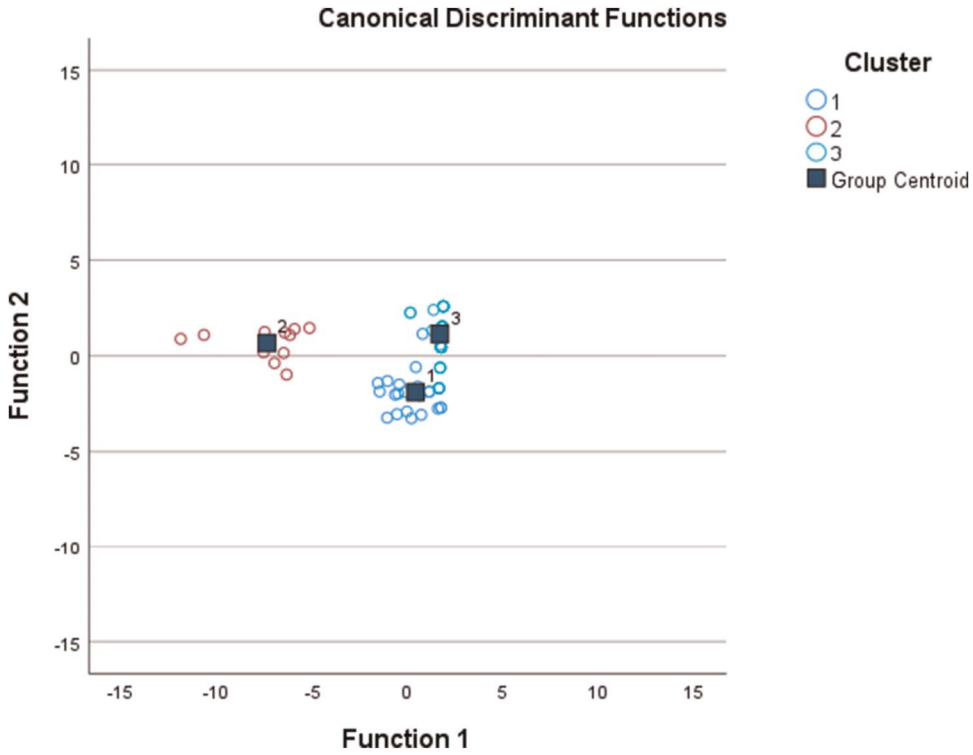


**Figure 2.** The two canonical discriminant functions, including cluster membership.

as MCI patients and as measured through the domains of basic monetary skills, bill payment, and bank statement management. Additionally, it supports that left-hander, although often excluded from study cohorts in neuroscience to reduce variance in the data,[18] should not be treated in a different way during neuropsychological assessment of financial capacity skills.

The above findings are in contrast to findings that rely on the hypothesis tested at another research, that being left-handed signifies a better decision-maker,[19] not due to brain differences, but due to lower anxiety levels as left-handed individuals may take their time over unfamiliar tasks and think through the consequences of decision-making in real life and in scenarios, and thus, left-hand dominance may be associated with a more cautious cognitive style in novel problem-solving situations.[17] In this way, left-handed individuals may counterpoise their "hypothesized" cognitive impairment-deficits compared with right-handed people and score the same as they do. This study also opens a new field of research for the unexplored differences in personality characteristics and more specifically differences in motivation to successfully complete the neuropsychological assessment that may influence the possible cognitive deficits in left-handed persons.

One of the major limitations of these preliminary results in this exploratory study is the small sample size. Additionally, apart from depressive symptomatology, which is of clinical interest in geriatric assessment (as it is a major influencing factor of neuropsychological performance), state-trait anxiety levels were not measured. In addition to that, individuals self-reported their hand preference without using a structured scale (eg, Edinburgh handedness inventory, EHI) to establish hand dominance and those that were naturally ambidextrous or those forced to change hand preference were excluded to avoid such influences. Future studies should include the abovementioned variables and further examine possible influences of such parameters.

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