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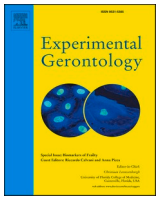

When cognitive efficiency meets life satisfaction in late adulthood: Insights from DIGICOG-MS performance among Sardinian older adults

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ABSTRACT

Life satisfaction is a key component of successful aging. This study investigated the correlates of life satisfaction in a sample of 127 older adults (M_{age} = 73.1 years, SD = 5.4) from Sardinia, an Italian island known for successful aging. Participants were assessed for global cognitive efficiency, perceived health, lifestyle habits, life satisfaction, and specific cognitive functions using the digital screening tool DIGICOG-MS. After controlling for age, education, and global cognitive efficiency, life satisfaction was significantly associated with perceived health, time spent on hobbies, verbal semantic fluency, auditory verbal learning, and immediate recall via DIGICOG-MS. A hierarchical regression analysis showed that perceived physical health, time spent on hobbies, verbal fluency, auditory verbal learning, and immediate recall were significant predictors of life satisfaction, accounting for approximately 20% of the variance (Adjusted R^2 = 0.198, F(8,117) = 4.860, $p < .001$). Interestingly, greater usability of DIGICOG-MS was associated with lower levels of education, suggesting that the tool is highly intuitive and successfully mitigates the educational barriers often encountered in traditional paper-and-pencil neuropsychological assessments. In conclusion, these findings highlight the role of subjective health, engagement in leisure activities, executive functions, auditory verbal learning, and immediate recall in shaping life satisfaction in late adulthood, supporting the potential of DIGICOG-MS as a tool for community-based cognitive screening in older populations.

1. Introduction

The maintenance of adequate levels of psychological well-being represents a major societal challenge in promoting healthy life expectancy for the growing global geriatric population (WHO, 2023). In this regard, life satisfaction is a fundamental facet of subjective well-being, reflecting an individual's evaluation of their overall quality of life (Diener et al., 2018) and playing a crucial role in successful aging (Baltes and Baltes, 1990; Diener and Chan, 2011). Although a consensus on the definition of life satisfaction is currently lacking — with conceptualizations oscillating between a unidimensional (Diener et al., 1985) and a multifaceted construct (Nakamura et al., 2022) — extensive literature shows that it is shaped by various objective and subjective determinants in late adulthood. For instance, it is well established that educational attainment, stable social networks, robust social support, sleep quality and duration, religiosity, marital status, concordant living arrangements, self-rated health status, and engagement in physical activity contribute, among others, to boosting life satisfaction in later life (e.g., Cheng and Yan, 2021; Khodabakhsh, 2022). In contrast, financial hardship (e.g., reduced income, rising living costs, inadequate pensions, or lack of retirement savings) might expose older individuals to postpone medical care, thereby significantly impacting their life satisfaction (Choi and Lee, 2023). However, to date, few studies have tried to fully disentangle the relative impact of these diverse determinants on life satisfaction in late adulthood. To address this issue, Kim and Lee (2026) recently adopted a cross-national perspective to examine how social context (i.e., interpersonal trust, institutional confidence, and social interaction), political governance (i.e., corruption, quality of governance, and level of democracy), economic conditions (i.e., inflation, unemployment, and economic growth), and demographic factors relate to the subjective well-being of individuals aged 50 and above across 58 countries. The authors concluded that being married, number of

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children, social group membership, institutional confidence, interpersonal trust, quality of governance, degree of democracy, self-rated health, income, and religion were positively associated with life satisfaction. Conversely, a negative association was found with inflation, while no significant relationships emerged regarding gender and education.

A further stream of research is examining the correlates of psychological well-being (including life satisfaction) in older populations undergoing successful aging, such as those living in the Blue Zones. These are geographically limited areas, experimentally validated (Poulain and Herm, 2025) and characterized by the exceptional longevity of their inhabitants compared to adjacent regions. Thus far, Blue Zones have been identified in Sardinia (Italy), Okinawa (Japan), Nicoya (Costa Rica), Ikaria (Greece), and Martinique (France). Studies carried out among their older inhabitants show that they lead simple yet active lifestyles, characterized by regular moderate-to-intense physical activity and strong social engagement. These factors, in turn, seem to contribute to high levels of psychological well-being and remarkably low rates of depressive symptoms (Legrand et al., 2019; Madrigal-Leer et al., 2020; Panagiotakos et al., 2011; Ruiu et al., 2022). Specifically, psychological research has documented that, while older Sardinians exhibit depressive symptoms well below the national cut-off (Ruiu et al., 2022), inhabitants of the Sardinian Blue Zone report higher life satisfaction than their peers recruited from the urban context of Cagliari (Fastame et al., 2021). Consistent with this, it has also been found that the degree of satisfaction with family and non-family members, perceived physical health, the low occurrence of depressive symptoms, carbohydrate intake, religiosity, and hours spent on leisure activities are significantly associated with life satisfaction among older individuals in the Sardinian Blue Zone (Fastame, 2022; Fastame et al., 2018, 2021, 2022). Extending this evidence, Fastame et al. (2014) also documented that older adults of the Sardinian Blue Zone reported higher life satisfaction, exhibited better verbal and visuo-spatial active working memory, and demonstrated superior metamemory compared to a peer group enrolled in a rural village of northern Italy. More recently, Pau et al. (2025) found that a more active lifestyle, characterized by greater engagement in moderate-to-vigorous physical activity, ensures better global cognitive efficiency, greater cognitive flexibility, and faster processing speed in older individuals of the Sardinian Blue Zone.

Overall, as reported elsewhere (e.g., Lee, 2025), better cognitive functioning represents a crucial determinant of life satisfaction in late adulthood. This association seems to be mediated by instrumental activities of daily living (IADLs; e.g., shopping, housekeeping, managing finances), which are essential for maintaining independence (Foong et al., 2023; Khodabakhsh, 2022). Therefore, as digital tools become deeply embedded in everyday life, there is an urgent need for rapid, easy-to-use, and self-administered applications to screen memory efficiency and detect early signs of cognitive impairment in older populations, given their critical importance for daily functioning. Within the Italian context, a highly promising avenue for addressing this need is DIGICOG-MS, a self-administered cognitive assessment app developed by the Italian Multiple Sclerosis Foundation to evaluate subtle but clinically significant cognitive symptoms in individuals with Multiple Sclerosis (MS). Previous evidence has shown DIGICOG-MS to be a valid, reliable, and highly usable digital instrument. Considering its brief administration time (approximately 20 min) and its solid psychometric properties, it is reasonable to expect its successful application in geriatric populations at risk of cognitive disorders (Podda et al., 2024b).

To the best of our knowledge, no studies have specifically explored the association between life satisfaction and cognitive functioning using a digital health cognitive screening tool in a typically developing older population characterized by high levels of psychological well-being, such as that of Sardinia. However, a recent study (Milič Kavčič et al., 2024) provided indirect evidence of a cognition–well-being relationship, demonstrating that older adults participating in a computerized cognitive training showed both improved cognitive performance and better well-being outcomes. Although that study did not directly examine the association between life satisfaction and working-memory efficiency using digital cognitive screening measures, it supports the broader hypothesis that cognitive functioning and subjective well-being may be closely interconnected in later life.

To, at least partly, address this gap, the current study was mainly aimed at: 1) examining the relationships between self-reported life satisfaction, health status, lifestyle (evaluated as time spent on hobbies), and cognitive functions (evaluated through the DIGICOG-MS digital screening tool) in a sample of cognitively healthy community-dwelling older adults; 2) assessing the contribution of the above-mentioned measures as correlates of life satisfaction in late adulthood, while controlling for global cognitive status and area of residence (i.e., Sardinian rural versus semi-urban contexts); 3) investigating the relationship between the perceived usability of DIGICOG-MS and participants'age, education, and global cognitive efficiency. Sardinia provided an ideal setting for this investigation, as it allows for the examination of life satisfaction and cognitive efficiency across distinct regional areas that, given their distance from the mainland, are less affected by external cultural influences. By recruiting participants from both rural and semi-urban Sardinian contexts outside the validated Blue Zone, this study captures a broader representation of the psychological, functional, and lifestyle characteristics of late adulthood in an insular context known for high perceived satisfaction and high life expectancy (ISTAT, 2025).

We hypothesized that life satisfaction would be positively associated with perceived health (e.g., Fastame et al., 2022; Kim and Lee, 2026), time spent on leisure activities (Fastame et al., 2022), and working memory efficiency (Fastame et al., 2014; Lee, 2025). Moreover, in line with previous evidence showing good usability and acceptability of digital cognitive tools among older adults (Bayer et al., 2024), we expected participants to report a positive perceived usability of DIGICOG-MS. Considering the exploratory nature of this study, no additional a priori hypotheses were proposed.

2. Method

2.1. Participants

A convenience sample of 127 community-dwelling older participants (M_{age} = 73.1, SD = 5.4, age range: 65–88 years) was enrolled in the study. The sample consisted of 96 females (75.59%) and 31 males. To capture potentially different aging trajectories, based on the territorial infrastructure availability, 48 participants were recruited from a traditional, rural, agropastoral village in northern Sardinia, whereas a subsample of 79 individuals was recruited from a University of the Third Age in a small, post-mining town in the south of the island. This latter cohort represented an intellectually active sub-population of older Sardinian adults. The inclusion criteria for participation were as follows: 1) being born and resident in Sardinia for at least two previous generations; 2) being a community-dweller; 3) the absence of moderate-to-severe cognitive impairment, operationalized as a Mini-Mental State Examination (MMSE, Folstein et al., 1975) score > 23.9. Notably, four participants with MMSE scores between 21.7 and 23.7 were included in the final sample. This deliberate inclusion was justified by their preserved functional independence in daily routines and their active, ongoing enrollment at the University of the Third Age, which attested a high level of spontaneous socio-cognitive engagement. To ensure that the inclusion of these four individuals did not bias the overall findings, a preliminary sensitivity analysis was conducted. The exclusion of these cases yielded no significant changes in the direction, magnitude, or statistical significance of the subsequent partial correlations and hierarchical regression models, thereby validating the robustness of the entire sample dataset. Overall, the mean MMSE score for the total sample was 26.9 (SD = 1.7).

2.2. Materials

The MMSE (Folstein et al., 1975) was administered to screen global cognitive efficiency, as this test evaluates different cognitive functions, including attention, working memory, and long-term memory. As suggested by Magni et al. (1996), scores were adjusted for age and years of education (maximum score = 30).

A socio-demographic interview, adapted from Fastame (2021), was administered to gather background (e.g., chronological age, marital status, educational attainment) and lifestyle (e.g., smoking, hobbies, reading) information from the participants.

The Life Satisfaction subscale of the Psychological Well-Being and Aging Questionnaire (LS-PWAQ, De Beni et al., 2007) was administered to assess participants' positive attitude towards their life. This 11-item subscale requires respondents to evaluate the frequency of specific statements (e.g., 'When I wake up in the morning, I feel happy with myself and my life') on a 5-point Likert scale ranging from 1 (never) to 4 (often), yielding a maximum total score of 44. Among septuagenarians, a score ≤ 30 indicates a low level of life satisfaction, a score between 31 and 36 falls within the average range, and a score > 36 reflects a high level of life satisfaction. The internal consistency of this subscale is expressed by $\alpha = 0.81$ (De Beni et al., 2007).

The EQ Visual Analogue Scale (EQ VAS) of the EQ-5D-5L (Herdman et al., 2003; Italian validation: Meregaglia et al., 2023) was administered to quantitatively assess the respondents' perceived health on a vertical scale ranging from 0 (i.e., "the worst health you can imagine") to 100 (i.e., "the best health you can imagine").

DIGICOG-MS is a smartphone- and tablet-based digital screening and monitoring tool developed by the Italian Multiple Sclerosis Foundation (FISM) to enable cognitive functioning self-assessment outside traditional clinical settings. The tool integrates four digital tests inspired by traditional paper-and-pencil tests, designed to assess visuospatial memory, auditory verbal learning and immediate recall, semantic fluency, and information processing speed (Podda et al., 2024b). The app includes four tasks as follows:

1. "Remember and place" assesses visuospatial memory. A 6 × 6 grid (36-squares) with 10 black checkers is displayed on the screen for 10 s. Once the pattern disappears, participants must reproduce it on a blank checkerboard. This replicates the 10/36 Spatial Recall Test (SPART; Amato et al., 2006). The test includes 3 consecutive trials, and the final score is the total number of correct responses across the 3 trials.
2. "Listen and repeat" was developed as an electronic version of the Rey Auditory Verbal Learning Test (RAVLT) by Carlesimo et al. (1996) to evaluate verbal learning and immediate recall. Participants listen to a prerecorded list of 15 common nouns and are asked to recall as many words as possible, repeated over five consecutive trials. Responses are recorded through speech recognition software and automatically converted into text using artificial intelligence (AI) with a high degree of accuracy. The total score consists of the cumulative number of words recalled across the five trials.
3. "Generate words" is a digital adaptation of the Word List Generation (WLG) test (Amato et al., 2006), which measures verbal semantic fluency. Participants are given 90 s to generate a list of words belonging to a specific semantic category. Responses are recorded through speech recognition software and automatically transcribed into text using AI. The total score is based on the number of correct words produced.
4. "Associate numbers" represents a modified electronic version of the Symbol Digit Modalities Test (SDMT; Amato et al., 2006), which measures attention and information processing speed. Participants are required to match single digits (1–9) to corresponding symbols as accurately and quickly as possible by clicking on an on-screen keyboard. A key pairing the digits with their respective symbols is available for the entire duration of the test, following a 4-item practice phase to familiarize participants with the task. A 90-s timer automatically terminates the procedure. The total score consists of the number of correct responses produced within 90 s. In addition, the number of correct digit-symbol pairings completed after 30 and 60 s is also recorded.

Finally, the Italian mHealth App Usability Questionnaire (patient version for stand-alone apps, Ita-MAUQ; Podda et al., 2024a) was administered to assess the perceived usability of DIGICOG-MS among the participants. It comprises three subscales —ease of use, interface and satisfaction, and usefulness— scored on a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). The total Ita-MAUQ score is computed as the sum of all items, with higher scores indicating greater perceived usability (maximum total score = 126). The Cronbach α for the Ita-MAUQ was 0.92 (Podda et al., 2024a).

2.3. Procedure

The study was conducted in accordance with the 1964 Helsinki Declaration and its later amendments and was approved by the Ethics Board of the research institution where the study was conducted. Written informed consent was provided by each participant before their participation.

Testing was conducted across two individual experimental sessions spaced one week apart. During the first session, the MMSE, the socio-demographic interview, the EQ VAS, and the LS-PWAQ measures were administered. One week later, participants were asked to complete the DIGICOG-MS tests. Both experimental sessions were conducted in a quiet room. To prevent fatigue effects, the examiner read aloud each statement of the socio-demographic interview, the test instructions, and the life satisfaction subscale items, subsequently recording the responses on the response sheet. Taken together, the two experimental sessions lasted approximately 50 min.

2.4. Statistical analyses

An a priori power analysis was conducted using the G-power program (Faul et al., 2007) to determine the minimum sample size required to detect moderate effect sizes with a statistical power ($1 - \beta$) of 0.80, and a significance level (α) of 0.05. To perform partial correlation analyses, using three covariates, the power analysis revealed that a convenient sample of 85 participants was required to detect a moderate effect of $r = 0.30$ with a statistical power of 0.80. Furthermore, to conduct a hierarchical regression analysis using 8 predictors, with 80% power, α at 0.05, and medium effect size ($f^2 = 0.15$), 109 participants were necessary.

To ensure the appropriateness of parametric analyses, the distributional characteristics of all continuous variables were examined. Descriptive statistical analyses were performed to examine the socio-demographic characteristics and lifestyle habits of the participants. Independent samples Welch's *t*-tests were conducted to examine potential differences between the two subsamples. Partial correlations were calculated to explore the nature of the relationships between life satisfaction, time spent on hobbies, perceived physical health, and DIGICOG-MS measures, controlling for the effects of age, education, and MMSE scores. Additionally, a hierarchical regression analysis was conducted to investigate the impact of general cognitive functioning (evaluated through the MMSE), area of residence, perceived health status (assessed through the EQ VAS), time spent on hobbies, and the four DIGICOG-MS measures as correlates of life satisfaction. Finally, Spearman's rank-order correlations were computed to examine the relationships between the perceived usability index of the DIGICOG-MS and age, global cognitive efficiency, and education. As suggested by Cohen (1988), effect sizes for correlation coefficients (including Spearman's ρ) were interpreted as small (≤ 0.29), medium (0.3–0.49), and large (> 0.49). All statistical analyses were conducted using IBM SPSS Statistics (version 24), with the

significance level set at $\alpha = 0.05$.

3. Results

Preliminary data screening indicated that while the MMSE score, years of education, time spent on hobbies, personal satisfaction, and DIGICOG-MS measures met the distributional assumptions for linear modelling, the EQ VAS scores violated the assumption of normality. Therefore, the EQ VAS index underwent a reflection and square-root transformation, and all subsequent analyses were conducted using the transformed EQ VAS variable. Importantly, because of the reflection applied during transformation, the direction of the original scale was inverted. Consequently, higher scores on the transformed EQ-VAS variable indicate lower perceived health, whereas negative coefficients reflect a positive relationship between actual perceived health and any dependent variable.

Descriptive analyses revealed that gender ($\chi^2 = 33.268$, df = 1, $p < .0001$), education level (i.e., low: 0–8 years of formal schooling vs. high: > 8 years, $\chi^2 = 17.394$, df = 1, $p < .0001$), and area of residence ($\chi^2 = 7.567$, df = 1, $p = .006$) were not equally distributed among participants. In contrast, gardening (yes vs. no, $\chi^2 = 2.276$, df = 1, $p = .131$), medication intake (yes vs no, $\chi^2 = 1.331$, df = 1, $p = .249$), and alcohol consumption (yes vs no, $\chi^2 = 3.472$, df = 1, $p = .062$) were homogeneously distributed across the sample. Participants reported a mean life satisfaction score of 35.04 (SD = 4.61), which falls within the average range for septuagenarians. Table 1 provides a detailed description of the socio-demographic characteristics and lifestyle habits of the participants stratified by area of residence.

To pursue the first goal, partial correlations using age, years of education, and the MMSE score as covariates revealed significant associations between life satisfaction and the transformed EQ VAS ($r = -0.257$, $p = .004$), time spent on hobbies ($r = 0.204$, $p = .023$), DIGICOG-MS "Generate words" ($r = -0.307$, $p < .001$), and DIGICOG-MS "Listen and repeat" ($r = -0.266$, $p = .003$), respectively. In contrast, no significant associations were found between life satisfaction and either DIGICOG-MS "Remember and place" ($r = -0.095$, $p = .292$) or DIGICOG-MS "Associate numbers" ($r = 0.099$, $p = .277$). Table 2 illustrates these findings.

Moreover, a four-step hierarchical multiple regression analysis was conducted to explore the contribution of time spent on hobbies, perceived physical health, and DIGICOG-MS scores as correlates of life satisfaction, while controlling for global cognitive status and area of residence. Preliminary analyses confirmed no violation of the assumptions of normality, linearity, multicollinearity, and homoscedasticity. Regarding multicollinearity, the Variance Inflation Factor (VIF) for all predictors was well below the conservative threshold of 2.5 (with VIF values ranging between 1.007 and 1.886), and tolerance values were safely above 0.20 (minimum tolerance = 0.530). This confirms the statistical stability and independence of the variables within the final regression model. The MMSE score and area of residence were entered at Step 1; perceived health status evaluated through the EQ VAS was added at Step 2; time spent on hobbies was inserted at Step 3; and the four DIGICOG-MS measures were entered at Step 4. Overall, the full model explained approximately 20% of the variance after adjusting for the number of predictors [$R^2 = 0.249$, Adjusted $R^2 = 0.198$, F (8,117) = 4.860, $p < .001$]. Table 3 summarizes these results.

Finally, a significant but negative association was found between perceived usability (measured via the Ita-MAUQ total score) and years of education ($r_s = -0.306$, $p < .001$), suggesting that less educated participants reported higher appreciation for the app. In contrast, no significant associations emerged between the Ita-MAUQ score and either age ($r_s = -0.166$, $p = .062$) or global cognitive functioning assessed through the MMSE ($r_s = -0.053$, $p = .552$).

Table 1
Socio-Demographic Characteristics of the Sample by Area of Residence. M denotes mean, whereas SD refers to standard deviation.

Variable	Rural agropastoral Area	Post-mining semi-urban Area	χ^2	Welch's *t*-test
n	48	79	7.567, p = .006	
Age (years), M (SD)	73.3 (6.3)	72.9 (4.9)		0.381, p = .704
Gender			3.330, p = .68	
Males	16	15		
Females	32	64		
Education (years), M (SD)	8.7 (4.7)	15.2 (4.7)		−7.596, p < .001
Education level			49.635, p < .001	
≤ 8 years	33	7		
> 8 years	15	72		
Marital status			5.846, p = .016	
Unmarried	38	46		
Married	10	33		
Medication intake			4.160, p = .041	
Yes	32	38		
No	16	41		
Daily smoking			0.182, p = .67	
Yes	4	5		
No	44	74		
Daily alcohol intake			5.011, p = .025	
Yes	14	39		
No	34	40		
Reading			29.700, p < .0001	
Yes	29	77		
No	19	2		
Watching television			6.797, p = .009	
Yes	44	79		
No	4	0		
Weekly hours spent on hobbies	6.9 (5.9)	6.2 (4.9)		0.748, p = .456
Weekly hours spent gardening	3.7 (6.6)	3.08 (4.7)		0.671, p = .503
MMSE Total, M (SD)	27.07 (1.3)	26.82 (1.9)		0.888, p = .376

Note. χ^2 tests are reported with degrees of freedom df = 1, whereas *t*-tests are reported with degrees of freedom df = 125.

4. Discussion and conclusions

The main goal of this study was to investigate the correlates of life satisfaction in a sample of community-dwelling older adults enrolled in Sardinia, focusing specifically on the contribution of memory functions evaluated through the DIGICOG-MS app, alongside perceived health and lifestyle habits.

Consistent with previous research (Kim and Lee, 2026), after controlling for age, education, and global cognitive efficiency, life satisfaction was positively associated with self-reported health status. This finding suggests that subjective health reflects individuals' perceived ability to maintain functional independence in daily life. Moreover, as expected (Fastame et al., 2022), a positive association was also found between life satisfaction and time spent on hobbies, confirming that engaging in cognitively stimulating and socially involving leisure activities (i.e., as a facet of cognitive reserve) promotes successful aging. Indeed, following the Activity Theory (Havighurst, 1961) and in line with previous studies (e.g., Fernández-Ballesteros, 2008; Foster and Walker, 2015), participation in enjoyable, cognitively, or physically stimulating activities not only provides pleasurable opportunities but may also foster social connectedness and favour adaptation to the aging process. Unexpectedly, negative associations emerged between life

Table 2
Partial correlations between life satisfaction and perceived health status (i.e., *EQ VAS), time spent on hobbies* (i.e., *Time-hobbies),* DIGICOG-MS Remember and place (i.e., Digi-place), *DIGICOG-MS Listen and repeat* (i.e., DIGI-Listen and repeat), *DIGICOG-MS generate words (DIGI-flu),* and DIGICOG-MS associate numbers (i.e., DIGI-numbers), controlling for age, educational attainment, and global cognitive efficiency.

	Personal satisfaction		EQ VAS	Time-hobbies	DIGI-place		DIGI-Listen and repeat		DIGI-flu	DIGI-numbers
Personal satisfaction	–									
EQ VAS	−0.257	**	–							
Time-hobbies	0.204	*	−0.163	–						
DIGI-place	−0.095		0.133	−0.088	–					
DIGI-Listen and repeat	−0.266	**	0.090	0.077	0.189	*	–			
DIGI-flu	−0.307	***	0.078	−0.144	0.243	**	0.433	***	–	
DIGI-numbers	0.099		−0.064	−0.065	0.151		0.194	*	0.166	–

Note. Control for age, years of education, and MMSE.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

Table 3
Summary of the hierarchical regression analysis for variables predicting life satisfaction. Global cognition (i.e., MMSE score) and area of residence were entered at Step 1. Perceived physical health (i.e., EQ VAS) was added at Step 2. The number of weekly hours spent on hobbies (Time-hobbies) was entered at Step 3, and the four DIGICOG-MS measures were added at Step 4.

Predictor	B	95% CI	β	t	p
Model 1					
Constant	32.775	[20.373, 45.176]		5.231	< 0.001
MMSE	0.135	[− 0.319, 0.590]	0.052	0.589	0.557
Area of Residence	−2.116	[− 3.759, −0.473]	- 0.224	- 2.549	0.012
Model 2					
Constant	40.080	[27.333, 52.827]		6.224	< 0.001
MMSE	0.003	[− 0.443, 0.448]	0.001	0.012	0.990
Area of Residence	- 2.690	[− 4.311, − 1.069]	- 0.285	- 3.285	0.001
EQ VAS	- 0.716	[− 1.152, − 0.280]	- 0.285	- 3.252	0.001
Model 3					
Constant	38.754	[26.029, 51.480]		6.029	< 0.001
MMSE	0.005	[− 0.437, 0.447]	0.002	0.022	0.983
Area of Residence	- 2.560	[− 4.173, − 0.946]	- 0.271	- 3.140	0.002
EQ VAS	- 0.644	[− 1.084, − 0.204]	- 0.256	- 2.900	0.004
Time-hobbies	0.131	[− 0.016, 0.278]	0.151	1.767	0.074
Model 4					
Constant	38.960	[26.767, 51.152]		6.238	< 0.001
MMSE	0.108	[− 0.330, 0.546]	0.041	0.488	0.626
Area of Residence	- 0.522	[− 2.420, 1.376]	- 0.055	- 0.544	0.587
EQ VAS	- 0.464	[− 0.903, − 0.026]	- 0.185	- 2.096	0.038
Time-hobbies	0.154	[0.009, 0.299]	0.177	2.109	0.037
DIGICOG-MS Remember and place	- 0.022	[− 0.185, 0.140]	−0.024	- 0.273	0.786
DIGICOG-MS Listen and repeat	- 0.100	[−0.189, −0.011]	- 0.244	- 2.215	0.029
DIGICOG-MS Generate words	- 0.147	[− 0.290, − 0.003]	−0.209	- 2.024	0.045
DIGICOG-MS Associate numbers	0.139	[− 0.009, 0.288]	0.170	1.857	0.066

satisfaction and individuals' performance on both the verbal semantic fluency task (i.e., DIGICOG-MS “Generate words”) and the auditory verbal learning and immediate recall (i.e., DIGICOG-MS “Listen and repeat”) task, even after adjusting for the effects of the covariates. At least three alternative interpretations may account for this pattern of results. First, this finding may reflect a statistical suppression effect due to the inclusion of age, education, and global cognitive efficiency as covariates, which may alter the direction of the associations. Second, older adults tend to prioritize positive information processing and experiences over the negative ones, remembering positive stimuli more readily than negative information, independently of their objective cognitive efficiency (Reed and Carstensen, 2012). Therefore, older participants reporting higher life satisfaction might focus more heavily on emotionally satisfying aspects of their lives rather than on the efficiency of their verbal memory and fluency functions, which are typically deployed to adapt to routine stressors and shifts associated with the aging process. Third, an alternative interpretation is that higher efficiency of verbal fluency, auditory verbal learning, and immediate recall abilities may reflect a sharper and unfiltered self-awareness of age-related changes and everyday limitations, paradoxically leading older individuals to report lower life satisfaction. Therefore, extending previous evidence (Zhang et al., 2024), these findings suggest that lower cognitive efficiency does not necessarily hinder older individuals — particularly those maintaining an active lifestyle, such as the current sample — from experiencing high life satisfaction.

The hierarchical regression analysis showed that when the DIGICOG-MS measures were entered in the final model, the previously robust statistical significance of the area of residence observed at Steps 1–3 was neutralized, whereas the effect of perceived health status remained significant. Indeed, the final model revealed that apart from perceived health status, time spent on hobbies, verbal fluency, auditory verbal learning, and immediate recall emerged as the most significant correlates of life satisfaction, explaining approximately 20% of the variance. The fact that geographical differences in life satisfaction were absorbed in the final model suggests that the socio-cultural context did not play a primary role in shaping participants' subjective well-being; instead, their differences seem to be related to lifestyle habits, perceived health, and verbal memory efficiency. This is a critical point, since participants from the semi-urban area of southern Sardinia were more highly educated and attended the University of the Third Age, which is recognized for enhancing cognitive reserve and cognitive efficiency, mitigating social isolation, and boosting subjective well-being through lifelong learning and structured socialization (e.g., Wenzel et al., 2024). However, descriptive analyses documented that despite the lower educational attainment of participants in northern Sardinia, no significant differences emerged between the groups regarding global cognitive efficiency or time dedicated to gardening or hobbies. Indeed, both groups were highly active, and this regular engagement in physical activity and cognitively and socially stimulating hobbies played a shared role in shaping their life satisfaction.

Regarding the perceived usability of DIGICOG-MS, the present

findings suggest that this tool was generally well accepted by older adults and that usability was not significantly associated with either age or global cognitive functioning, as measured by MMSE. This suggests that neither advanced age nor lower general cognitive efficiency necessarily represent a barrier to interacting with digital assessments. This interpretation is consistent with previous studies reporting that older adults can successfully engage with digital cognitive tools, yielding satisfactory usability and acceptability metrics when such instruments are appropriately designed (Bayer et al., 2024).

Unexpectedly, years of education showed a significant negative association with perceived usability, indicating that participants with lower educational attainment reported more favorable usability ratings. This contrasts with Wu et al. (2025), who found that older adults with lower educational levels reported that digital tests were harder to learn and evaluated system usability more negatively. Although our finding may appear counterintuitive, perceived usability is a subjective construct that may reflect not only actual ease of use, but also differences in expectations, evaluative standards, and prior experience with technology. It is reasonable to speculate that participants with higher education adopted a more critical appraisal of the digital tool, whereas less educated individuals evaluated the experience more positively. Nonetheless, this pattern should be interpreted cautiously, as perceived usability evaluations do not necessarily mirror objective performance or the absence of minor difficulties during administration.

From an applied perspective, at least two main conclusions can be drawn. First, lower efficiency in specific memory and executive functions domains (e.g., verbal memory and verbal fluency) does not inherently compromise an older adult's capacity to experience high life satisfaction, provided they maintain an active lifestyle. Therefore, interventions promoting cognitively stimulating activities should be encouraged to boost psychological well-being in the last decades of life. Second, although DIGICOG-MS was originally designed to evaluate memory efficiency in individuals with MS, its specific verbal fluency, auditory verbal learning, and immediate recall subtests proved to be more sensitive than the MMSE in capturing variance in older individuals' life satisfaction. Therefore, DIGICOG-MS represents a free, open-source, and easy-to-administer resource that offers a promising option for future assessments aimed at identifying nuanced cognitive profiles in older adults.

However, the current study has several limitations that need to be acknowledged. First, the cross-sectional design precludes any definitive causal inferences regarding the direction of the relationships between cognitive efficiency, perceived health, lifestyle habits, and life satisfaction. Future longitudinal studies are required to determine the directional trajectory of these variables over time. Second, health status was assessed exclusively via the self-reported EQ VAS. While subjective health perception is widely recognized in gerontological literature as a powerful predictor of well-being and functional independence, an objective and more exhaustive evaluation of physical health by external examiners should be incorporated in future research using experimentally robust, objectively validated measures (e.g., Timed Up and Go, handgrip strength). Third, although DIGICOG-MS provided valuable granular data, the overall cognitive battery was relatively limited. Therefore, future research should include a broader psychological battery of tools to assess other cognitive domains in greater detail, such as active visual and spatial working memory and non-verbal long-term memory, inhibition, planning, and updating functions. Fourth, the sample consisted exclusively of community-dwellers from a region (i.e., Sardinia) renowned for exceptional longevity, which may limit the generalizability of the findings to other geographical contexts. Fifth, most participants maintained a highly active lifestyle, and a significant portion of them was enrolled in a lifelong educational organization, the University of the Third Age, which typically attracts more educated individuals. Therefore, this introduced a selection bias that limits the generalizability of the current findings to frailer, more sedentary, or institutionalized older individuals. Hence, future cross-cultural research involving larger cohorts of older participants — including both community-dwelling individuals and nursing home residents across diverse socio-cultural contexts — is needed to overcome these limitations. Additionally, a significant gender imbalance characterizes the current sample, with women representing approximately 75% of participants. Although this distribution reflects an internationally recognized demographic phenomenon in older populations as well as typical attendance trends observed in lifelong learning programs (e.g., Zielińska-Więczkowska and Sas, 2020), these findings should be interpreted and generalized with caution, and future research should strive for a more balanced gender representation. Lastly, the final hierarchical regression model accounted for approximately 20% of the variance in life satisfaction. While this magnitude is entirely consistent with psychological research on this complex and multifaceted construct in late adulthood (Puvill et al., 2016; Rashedi et al., 2025), the proportion of variance explained is meaningful yet modest. Overall, these results imply that the remaining 80% of the variance is shaped by other variables not captured in this study. Therefore, future research should investigate the association of life satisfaction with additional factors, such as coping strategies, anxiety, financial status, social network size, and frequency of social contacts.

In conclusion, these findings demonstrate that life satisfaction in late adulthood is closely linked to an active lifestyle and specific cognitive resources (e.g., cognitive flexibility), which can be effectively mapped using accessible and valid digital screening tools like DIGICOG-MS.

CRediT authorship contribution statement

Maria Chiara Fastame: Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization, Writing – review & editing. **Anna Atzori:** Project administration, Data curation. **Martina Di Dio:** Project administration, Data curation. **Massimiliano Pau:** Writing – review & editing, Funding acquisition, Formal analysis. **Alessia Susini:** Data curation. **Jessica Podda:** Writing – review & editing, Conceptualization.

Contributors

The first author conceived and designed the study, analyzed the data, drafted the manuscript, and was in charge of overall direction and planning. The second and third authors recruited the participants, collected the data, and were responsible for the scoring and database preparation s. The fourth author contributed to the conceptualization of the study and data analysis. The fifth and sixth authors supervised the administration procedure and scoring of the DIGICOG-MS measures. Additionally, the sixth author contributed to writing the manuscript. All authors approved the manuscript.

Informed consent

Written informed consent was given by all participants prior to participation.

Compliance with ethical standards

The study was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments. The protocol used in the current study was approved by the Ethics Commission of the University of Cagliari (Protocol No. 0103174 released on 09/04/2025).

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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