Journal of the International Neuropsychological Society (2024), **30**, 841–855
doi:10.1017/S1355617724000390

Research Article

Norms for neuropsychological tests in cognitively healthy French oldest old adults

Eva Sizaret[1,2], Maxime Brachet[3], Alix Launay[2,3], Christophe Destrieux[1,4], Ilyess Zemmoura[1,4], Lucie Angel[2] and the FIBRATLAS Consortium

[1]UMR 1253 iBraiN, Université de Tours, Inserm, Tours, France, [2]UMR 7295 CeRCA, Université de Tours, Université de Poitiers, CNRS, Tours, France, [3]CMRR, CHRU de Tours, Tours, France and [4]Service de Neurochirurgie, CHRU de Tours, Tours, France

Abstract

Objective: Normal aging often leads to cognitive decline, and oldest old people, over 80 years old, have a 15% risk of developing neurodegenerative diseases. Therefore, it is important to have appropriate tools to assess cognitive function in old age. The study aimed to provide new norms for neuropsychological tests used to evaluate the cognitive abilities in people aged 80 years and older in France, focusing on the impact of education and gender differences. **Method:** 107 healthy participants with an average age of 85.2 years, with no neurological history or major cognitive deficits were included. A comprehensive neuropsychological assessment was performed, covering several cognitive functions such as memory, visuospatial abilities, executive functions, attention, processing speed, and praxis. **Results:** Individuals with lower levels of education performed poorly on some tests and took longer to complete. Gender differences were observed, with women outperforming men in verbal episodic memory, while men showed better performance in visuoconstructive tasks. The participants showed lower performance in verbal episodic memory compared to norms established in previous French studies. In relation to executive functions, participants were slower to perform complex tasks than participants in previous studies. **Conclusion:** This study provides cognitive norms specifically adapted to the oldest old population, which differ from established norms for younger aging adults. It highlights the importance of including these norms in future clinical and scientific investigations. The findings underscore the importance of education on cognitive abilities and emphasize the need to consider gender differences when assessing cognitive functions in aging populations.

Keywords: Old age; cognitive function; normative data; neuropsychological tests; memory; executive function

(Received 23 September 2023; final revision 23 June 2024; accepted 25 June 2024; First Published online 18 September 2024)

Introduction

The demographic of the aging population in France, particularly those aged over 80, is significant and growing. According to Eurostat (2022), there are currently over 4.1 million people over 80 in France, accounting for 6.2% of the total population (Eurostat, 2022). It is projected that the number of people over 80 will double by 2070 making up 1 in 8 people in the country. Neurodegenerative diseases affect 6.4% of the population. Their prevalence increases with age, from 1.2% between 65 and 69 years, to 15% after 80 years and almost 30% after 90 years old (Gil, 2018).

The importance of recent cognitive function standards in the oldest old population lies in its ability to distinguish between pathological aging and successful or normal aging, as defined by Hartley et al. (2018). A comprehensive neuropsychological assessment also enables better tailoring of interventions to individuals in need.

Normal aging causes changes in cognitive functions (Angel & Isingrini, 2015; Braver & West, 2008; Cabeza et al., 2016; Goh et al., 2012; Park & Reuter-Lorenz, 2009). Salthouse (2019) reported that declines in episodic memory and reasoning skills accelerate around the age of 65. Processing speed declines linearly from the 30s, while vocabulary decline is less pronounced. Procedural memory is resistant to cognitive aging.

Several studies have investigated the impact of individual factors, such as education level and gender, on cognitive performance in old age. Research consistently shows a positive correlation between higher education and better cognitive performance among older individuals (Fletcher et al., 2021; Grasset et al., 2018; Opdebeeck et al., 2015), which supports the cognitive reserve hypothesis (Stern, 2002, 2009). Seblova et al. (2020) conducted a recent review and concluded that education was strongly correlated with performance levels but that the association between educational level and changes in cognitive performance was not significant. In a meta-analysis, Lövdén et al. (2020) found that education plays a significant role in cognitive function during later life by creating differences in cognitive abilities established in early adulthood that persist into old age.

Corresponding author: Eva Sizaret; Email: eva.sizaret@univ-tours.fr

Cite this article: Sizaret E., Brachet M., Launay A., Destrieux C., Zemmoura I., Angel L & the FIBRATLAS Consortium. (2024) Norms for neuropsychological tests in cognitively healthy French oldest old adults. *Journal of the International Neuropsychological Society*, **30**: 841–855, https://doi.org/10.1017/S1355617724000390

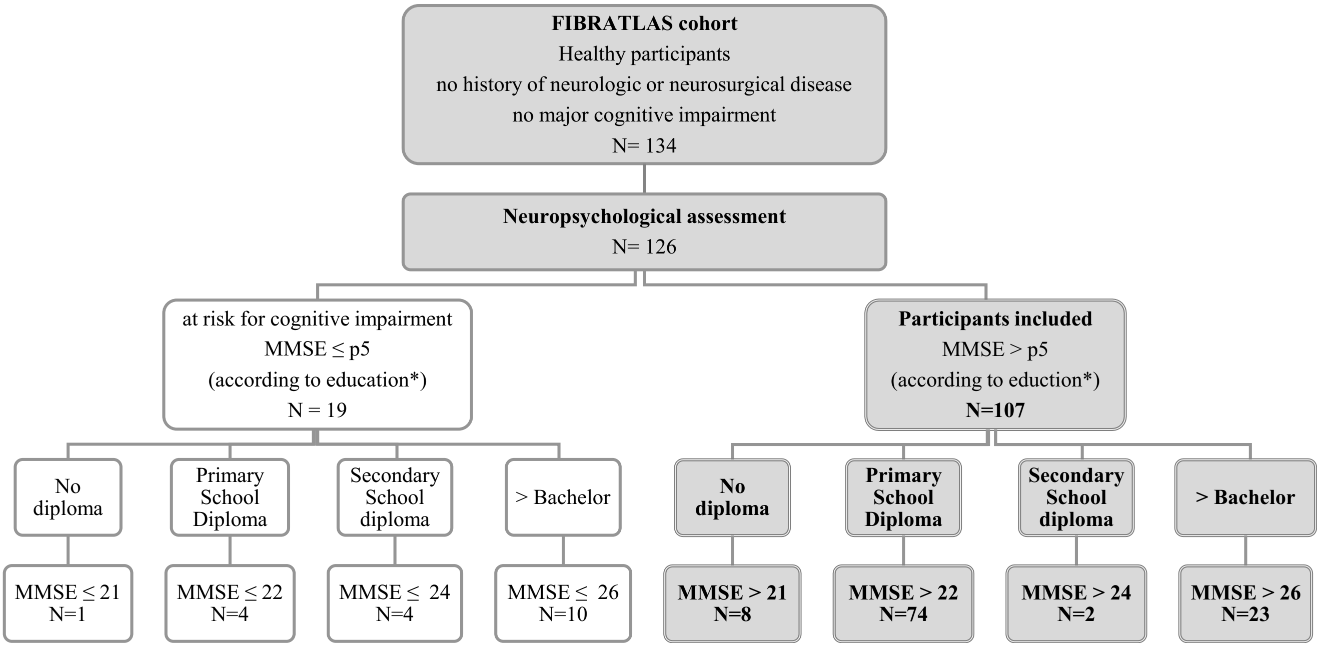

Figure 1. Flowchart of participant inclusion. *Note:* MMSE = Mini Mental State Examination. p5 = percentile 5. *using French norms from Kalafat et al. (2003).

Gender differences in cognitive aging have been extensively studied. Older men tend to outperform women in visual perceptual and visuoconstructive tasks, while older women show superior performance in the verbal domain (Munro et al., 2012; McCarrey et al., 2016; Proust-Lima et al., 2008). Further, McCarrey et al. (2016) found that men experience more cognitive decline in global efficiency, processing speed, and visuospatial ability, while older women are more resistant to age-related cognitive decline. These findings partially contrast with a recent study by Levine et al. (2021), which showed that women experience faster cognitive decline than men in global cognition and executive functions.

These different studies clearly demonstrate the impact of education and gender on cognitive function in aging. It is important to consider these factors when establishing standards for cognitive function.

According to Giulioli and Amieva (2016), the oldest old population is at a higher risk of developing a neurodegenerative disease. However, four out of five patients do not receive the recommended diagnostic procedures. Neuropsychological assessment in the oldest old can be challenging due to comorbidities, chronic pain syndromes, sensory deficits, or severe fatigue. Furthermore, there is a lack of cognitive tools and standards specifically designed for this population. Some studies have established French standards, particularly for individuals over 80.

In 2008, Roussel and Godefroy compiled the tests commonly used to assess executive function in the GREFEX battery and published normative scores for the French-speaking population. The age range of the oldest group remains broad, including subjects aged 60 and over, and does not distinguish a category of oldest old subjects. Overall, this 60 and over age group performed less well than younger age groups on all tests, both in terms of accuracy and reaction time. With the exception of the semantic fluency task, a lower level of education had a negative impact on all tests, while gender did not have any effect.

Ferreira et al. (2010) created the RAPID battery, a set of neuropsychological tests previously standardized in different populations. The study found a positive correlation between high educational level and cognitive functioning. Furthermore, scores were generally lower for the oldest age group (80 to 89) compared to the younger age groups, at each level of education.

Established in 1999–2000, the three Cities cohort is a large prospective cohort that includes French participants aged over 65 (The 3C Study Group, 2003). Amieva et al. (2007) developed detailed norms for an episodic memory test, the Free and Cued Selective Reminding Test (FCSRT), for people aged 65 years and over, with a specific group of subjects aged 78 to 90 years old, distinguished by gender and educational level. Statistical tests were not conducted on variables such as gender, age or education.

The Aging Multidisciplinary Investigation cohort, as described by Pérès et al. (2012), is a prospective epidemiological study that focuses on health and aging. The study produced normative data on a specific population of retired farmers aged 65 years and older, who live in rural areas. Rullier et al. (2014) used this cohort to provide detailed normative data for a visual recognition test (DMS-48). The study showed that test performance declined with age but increased with education. Additionally, women had significantly higher performance levels.

Giulioli et al. (2016) provided normative scores from a sample of healthy subjects aged 85 years and older from the Personnes Agées QUID study, 20 years after their inclusion. The study revealed that cognitive performance was negatively impacted by aging and lower education, except for a subtest assessing semantic ability. Gender did not have a significant effect after adjusting for age and education.

In conclusion, the limited research on French norms of neuropsychological assessment in the oldest old has not consistently considered the impact of gender and education. Furthermore, some cohorts have used tests that are not aligned with current clinical practice. The main aim of this study is to establish French standards, for individuals over 80 years old, based on commonly used neuropsychological assessment tests. These tests should be conducted under conditions that closely resemble

https://doi.org/10.1017/S1355617724000390

clinical practice, taking into account gender and education. Therefore, we propose measuring cognitive performance, including global cognitive function, language, memory, executive function, praxis, visuospatial ability, attention, and processing speed, in a single session on a population aged over 80. We will investigate the effect of gender and educational level variables on the entire group. It is hypothesized that individuals over the age of 80 will perform significantly lower than the existing norms for elderly populations. Furthermore, we anticipate that those with higher levels of education will perform better overall. It is also expected that men will perform better than women on visuoconstructive tasks while women will outperform men on verbal tasks.

Method

Participants

The FIBRATLAS Project (https://anr.fr/Projet-ANR-14-CE17-0015) recruited 134 participants from six French body donation programs. The project aims to validate in vivo and *ex vivo* MRI tractography of the brain's white matter using dissection as a gold standard. It has created a database containing in vivo (DWI MRI and neuropsychological assessment) and *ex vivo* (DWI and dissection) data obtained from the same subjects. The study involved 134 participants aged 82 or older with no history of neurological or neurosurgical disease or major cognitive impairment. Participants had a score of 4 or more on the Instrumental Activities of Daily Living scale.

Of the participants, 126 underwent a comprehensive neuropsychological assessment between 2015 and 2021 (see below). Nineteen participants, whose Mini-Mental State Examination (MMSE) scores were at or below the 5th percentile (using French norms with education level established by Kalafat et al., 2003) were excluded due to the risk of cognitive impairment (see Figure 1 for details).

A total of 107 participants were selected for analysis, consisting of 56 women and 51 men, with an average age of 85.2 (range: 82–94.5). The majority of participants (90%) were between the ages of 82 and 89, as shown in Table 1.

Table 1. Age distribution

Age	Counts	% of Total	Cumulative %
82	33	30.8 %	30.8 %
83	21	19.6 %	50.5 %
84	10	9.3 %	59.8 %
85	6	5.6 %	65.4 %
86	8	7.5 %	72.9 %
87	10	9.3 %	82.2 %
88	4	3.7 %	86.0 %
89	4	3.7 %	89.7 %
90	3	2.8 %	92.5 %
91	3	2.8 %	95.3 %
92	1	0.9 %	96.3 %
93	3	2.8 %	99.1 %
94	1	0.9 %	100.0 %

The Educ - group comprised 55 participants, with less than or equal to 9 years of education, corresponding to no diploma or primary school diploma. The Educ + group comprised 52 participants, with more than 9 years of education, corresponding to a secondary school or university diploma (see Table 2). There was no significant age difference between the male and female groups. However, there was a significant and moderate difference in age between the groups divided by level of education (Educ − vs. Educ +), both for the group as a whole (U (107) = 1039; $p = .015$; $r_{\text{rb}} = .274$) and for the female group (U (56) = 251; $p = .025$; $r_{\text{rb}} = .352$). The female participants with the lowest level of education were older, with a mean age of 86.6 years ($SD = 3.31$) for the Educ – group and 84.6 years ($SD = 2.85$) for the Educ + group, representing a difference of 2 years. The evaluation of depression was conducted using the Montgomery and Asberg Depression Rating Scale (Montgomery and Asberg, 1979), resulting in a mean score of 5.91 ($SD = 6.88$). Table 2 also reports the number of participants with cardiovascular risk factors, including diabetes, hypertension, and hypercholesterolemia.

Neuropsychological assessment

Neuropsychological assessments were conducted by psychologists within 45 days of inclusion, using normative tests commonly proposed in clinical practice. The assessments covered several domains including global cognitive function, language, episodic memory, visuospatial ability, executive function, attention, processing speed and praxis. Table 3 lists the neuropsychological tests, scores and times examined. Detailed procedures and scoring are described in the supplementary material.

The study assessed global cognitive function using the French version of the MMSE (Kalafat et al., 2003). Language ability was evaluated using the DO 80 picture naming test (Deloche and Hannequin, 1997), which allowed for spontaneous self-correction and strict marking, without strict time constraints. Episodic memory was evaluated in two modalities. The study used the FCSRT to assess auditory verbal memory. The FCSRT was adapted into French by Van der Linden et al. (2004) and in our study, we renamed the French version of the test RL/RI-16 to FCSRT-Fr to improve its clarity. The test assesses immediate recall, free and cued recalls, recognition and 20-minute delayed recall tasks. Visual episodic memory was evaluated using the DMS-48 (Barbeau et al., 2004). The evaluation included an immediate recognition task after an encoding phase, followed by a delayed recognition task presented one hour later. Visuospatial ability was assessed using the Rey Complex Figure Test (RCFT), which includes tasks such as copying, immediate reproduction, and delayed recall after 20 minutes (see Fastenau et al., 1999 for a description). To assess attention and executive function, tests adapted into French and standardized by GREFEX (Reflection Group on the Evaluation of Executive Function) were used, as documented by Meulemans (2008) and Roussel and Godefroy (2008). The Verbal Fluency Test, Stroop Test and TMT Part A and B were administered, along with the Digit Span subtest from the WAIS IV (Wechsler, 2011). Processing speed was measured using the Coding subtest of the WAIS IV (Wechsler, 2011). Gestural praxis was assessed using the Mahieux-Laurent Battery (MLB), which includes symbolic and meaningless gestures and action pantomimes (Mahieux-Laurent et al., 2009).

Figure 2 presents the order of the tests. The number of participants varied between 90 and 107, depending on the subtests, as some test data were not available (see Appendix 1 for details). The RCFT Delayed Recall subtest, the Stroop subtests, and TMT Part B were administered in the middle of the neuropsychological evaluation and had the lowest percentage of valid observations. Some participants experienced difficulties with certain subtests due to visual impairments (such as low visual acuity or poor color perception), or academic difficulties (such as poor writing or visuospatial skills). A small number of participants even refused to continue or expressed anxiety.

https://doi.org/10.1017/S1355617724000390

Table 2. Characteristics of the study participants

	Sex	Education	*N*	Mean	Median	SD	Min.	Max.
Age	Female	Educ −	31	86.6	86.4	3.31	82.0	93.7
		Educ +	25	84.6	83.4	2.85	82.0	92.6
	Male	Educ −	24	85.1	83.6	3.54	82.0	94.5
		Educ +	27	84.2	82.9	2.46	82.0	91.3
	Total		**107**	**85.2**	**83.9**	**3.17**	**82.0**	**94.5**
MMSE	Female	Educ −	31	26.4	26	2.17	23	30
		Educ +	25	28.3	29	1.44	25	30
	Male	Educ −	24	26.9	27.0	1.79	24	30
		Educ +	27	27.9	28	1.17	25	30
	Total		**107**	**27.4**	**27**	**1.85**	**23**	**30**
MADRS	Female	Educ −	29	8.62	5	9.30	0	36
		Educ +	25	5.44	5	4.54	0	15
	Male	Educ −	24	6.13	4.5	6.62	0	24
		Educ +	27	3.26	2	4.74	0	21
	Total		**105**	**5.91**	**4**	**6.88**	**0**	**36**
Associated medical conditions	Diabetes		9					
	Hypertension		64					
	Hypercholesterolemia		40					

Note: Educ − = less or equal to 9 years of education; Educ + = more than 9 years of education; SD = Standard Deviation; MMSE = Mini-Mental State Examination; MADRS = Montgomery-Asberg Depression Rating Scale.

Table 3. Neuropsychological test battery

Tests	Range of scores	Unit of times	Domains
MMSE	0–30 points	–	**Global**
DO 80	0–80 points	–	**Language**
FCSRT-Fr			**Episodic memory**
Immediate Recall	0–16 points	–	
Free Recalls	0–48 points	–	
Total Recalls	0–48 points	–	
Recognition	0–16 points	–	
Delayed Free Recall	0–16 points	–	
Delayed Total Recall	0–16 points	–	
DMS-48			**Episodic memory**
Encoding	–	seconds	
Immediate Recognition	0–48 points	seconds	
Delayed Recognition	0–48 points	seconds	
RCFT			**Visuospatial abilities**
Copy	0–36 points	seconds	
Immediate Recall	0–36 points	seconds	
Delayed Recall	0–36 points	seconds	
Verbal Fluency			**Executive function**
Literal (P)	0–max	120 sec.	
Semantic (animals)	0–max	120 sec.	
Stroop Test			**Executive function**
Naming	0–max *(NCE)*	seconds	
Reading	0–max *(NCE)*	seconds	
Interference	0–max *(NCE)*	seconds	
Interference - Naming	0–max *(NCE)*	seconds	
TMT			**Executive function**
TMT A	0–max (errors)	seconds	
TMT B	0–max (errors)	seconds	
TMT B-A	–	seconds	
Digit Span			**Executive function**
Forward		–	
Score	0–16 points		
Span	2–9 items		
Backward		–	
Score	0–16 points		
Span	2–9 items		
Sequencing		–	
Score	0–16 points		
Span	2–9 items		
Coding	0–135 items	120 seconds	**Attention and Speed processing**
MLB			**Praxis**
Symbolic Gestures	0–5 points	–	
Action Mimes	0–10 points	–	
Meaningless Gestures	0–8 points	–	

Note: MMSE = Mini Mental State Examination, FCSRT-Fr = Free and Cued Selective Reminding Test - French. RCFT = Rey Complex Figure Test, NCE = Non-Corrected Errors, MLB = Mahieux-Laurent Battery.

Table 4. MMSE: results (percentiles, mean, SD) and effects of education and gender

	Female		Male			Group comparison		
	Educ −	Educ +	Educ −	Educ +	Total		*p*	
p5	23	25	25	26	24	**Educ − vs Educ +**		
p10	23	27	25	27	25	Male	**.037**	**Educ − < Educ +**
p25	25	27	25	27	26	Female	**.001**	**Educ − < Educ +**
p50	**26**	**29**	**27**	**28**	**27**	Whole group	**.0001**	**Educ − < Educ +**
p75	28	29	29	29	29	**Male vs Female**		
p90	29	30	29	29	30	Educ −	.440	
p95	30	30	30	30	30	Educ +	.184	
Mean	*26.42*	*28.32*	*26.92*	*27.93*	*27.36*	Whole group	.906	
(SD)	*2.17*	*1.44*	*1.79*	*1.17*	*1.85*			

Table 5. DO80: results (percentiles, mean, SD) and effects of education and gender

	Female		Male			Group comparison	
	Educ −	Educ +	Educ −	Educ +	Total		*p*
p5	74	72	75	76	74	**Educ − vs Educ +**	
p10	77	76	76	78	76	Male	.335
p25	78	79	78	79	78	Female	.157
p50	**79**	**79**	**79**	**79**	**79**	Whole group	.072
p75	79	80	80	80	80	**Male vs Female**	
p90–p95	80	80	80	80	80	Educ −	.549
Mean	*78.03*	*77.16*	*78.48*	*78.81*	*78.13*	Educ +	.855
(SD)	*(3.01)*	*(8.56)*	*(1.75)*	*(2.18)*	*(4.67)*	Whole group	.422

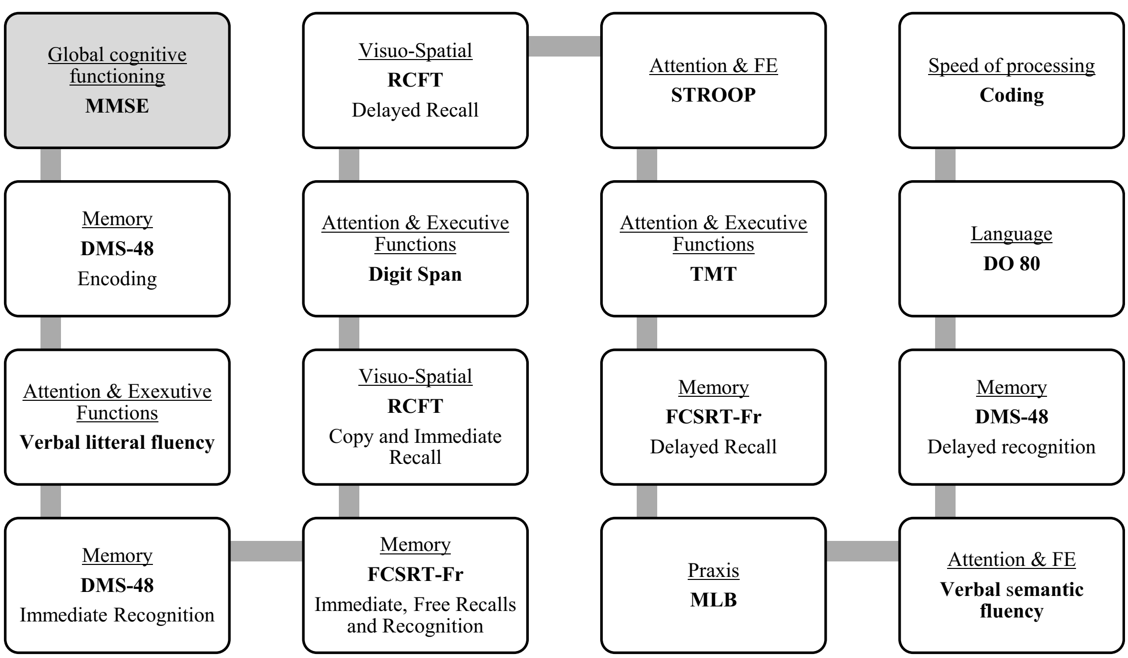

Figure 2. Domains assessed and tests administrated in order of presentation. *Note:* MMSE: Mini Mental State Examination. RCFT: Rey Complex Figure Test. FCSRT-Fr: Free and Cued Selective Reminding Test - French. MLB: Mahieux-Laurent Battery.

Ethic issues

Informed and written consent was obtained from all participants. This study adhered to the Ethical Principles for Medical Research Involving Human Subjects laid down in the Declaration of Helsinki. Additionally, the FIBRATLAS Project, from which part of the data was obtained, was approved by the Tours Ethics Committee (Comité de Protection des Personnes, 2015-R8) and by the ANSM (Agence Nationale de Sûreté du Médicament et des Produits de Santé, EudraCT/ID RCB: 2015-A00363-46).

Table 6. FCSRT-Fr: results (percentiles, mean, SD) and effects of education and gender (part 1)

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		*p*	
Immediate Recall	p5	14	14	11	13	12	**Educ − vs Educ +**		
	p10	14	14	11	13	13	Male	.088	
	p25	15	16	13	14	15	Female	.361	
	p50	**16**	**16**	**15**	**15**	**16**	Whole group	.135	
	p75–p95	16	16	16	16	16	**Male vs Female**		
							Educ −	**.008****	**Male < Female**
	Mean	*15,43*	*15,56*	*14,13*	*15,04*	*15,07*	Educ +	.085	
	(SD)	*(0.77)*	*(0.96)*	*(1.90)*	*(1.26)*	*(1.36)*	Whole group	**.003****	**Male < Female**
Free Recalls	p5	10	16	9	15	11	**Educ − vs Educ +**		
	p10	11	18	11	15	14	Male	**.044***	**Educ − < Educ +**
	p25	16	23	16	20	18	Female	**.028***	**Educ − < Educ +**
	p50	**24**	**28**	**20**	**22**	**23**	Whole group	**.007****	**Educ − < Educ +**
	p75	28	31	24	27	28	**Male vs Female**		
	p90	34	33	26	29	31	Educ −	.143	
	p95	34	34	27	31	34	Educ +	**.013***	**Male < Female**
	Mean	*22.38*	*26.72*	*19.39*	*22.74*	*22.86*	Whole group	**.016***	**Male < Female**
	(SD)	*(7.85)*	*(5.91)*	*(6.24)*	*(5.21)*	*(6.81)*			
Total Recalls	p5	28	43	31	37	35	**Educ − vs Educ +**		
	p10	37	43	35	38	38	Male	**.005****	**Educ − < Educ +**
	p25	43	45	39	44	43	Female	.138	
	p50	**45**	**47**	**42**	**46**	**45**	Whole group	**.004****	**Educ − < Educ +**
	p75	47	48	46	47	47	**Male vs Female**		
	p90–p95	48	48	47	48	48	Educ −	**.021***	**Male < Female**
	Mean	*43.76*	*46.00*	*40.91*	*44.85*	*43.95*	Educ +	.245	
	(SD)	*(5.47)*	*(2.16)*	*(6.34)*	*(3.43)*	*(4.91)*	Whole group	**.025***	**Male < Female**

Table 7. FCSRT-Fr: results (percentiles, mean, SD) and effects of education and gender (part 2)

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		*p*	
Recognition	p5	13	15	15	15	14	**Educ − vs Educ +**		
	p10	14	15	15	15	15	Male	.508	
	p25	15	16	15	16	16	Female	.323	
	p50–p95	**16**	**16**	**16**	**16**	**16**	Whole group	.227	
							Male vs Female		
							Educ −	.847	
	Mean	15.52	15.80	15.61	15.81	15.68	Educ +	.884	
	(SD)	*(0.91)*	*(0.65)*	*(0.89)*	*(0.48)*	*(0.75)*	Whole group	.909	
Delayed Free Recall	p5	4	5	0	5	3	**Educ − vs Educ +**		
	p10	6	6	3	5	5	Male	.164	
	p25	8	9	4	8	8	Female	.119	
	p50	**9**	**11**	**8**	**9**	**9**	Whole group	.069	
	p75	11	12	10	11	11	**Male vs Female**		
	p90	14	13	12	12	13	Educ −	.135	
	p95	14	14	12	14	14	Educ +	.052	
	Mean	*9.18*	*10.36*	*7.48*	*9.11*	*9.07*	Whole group	**.022***	**Male < Female**
	(SD)	*(3.15)*	*(2.71)*	*(3.76)*	*(2.41)*	*(3.14)*			
Total Delayed Recall	p5	13	15	10	13	12	**Educ − vs Educ +**		
	p10	14	15	10	14	13	Male	.113	
	p25	15	15	13	15	15	Female	.964	
	p50	**16**	**16**	**15**	**16**	**16**	Whole group	.377	
	p75–p95	16	16	16	16	16	**Male vs Female**		
							Educ −	**.023***	**Male < Female**
	Mean	*15.46*	*15.64*	*13.74*	*15.33*	*15.09*	Educ +	.336	
	(SD)	*(1.14)*	*(0.57)*	*(3.63)*	*(0.92)*	*(2.01)*	Whole group	**.025***	**Male < Female**

Data analysis

The statistical analyses were performed using Jamovi 2.4.14 software. The study examined the impact of gender and education on participants' cognitive performance. The scores were analyzed by gender (male vs. female) and education (Educ − vs. Educ +).

The study assessed the impact of gender on the entire sample and separately for each education group (Educ + vs. Educ −). Additionally, the effect of education was tested for each score globally (on the whole sample) and separately for each gender group (males vs. females). To determine the appropriate statistical tests, the Shapiro-Wilk test was used to assess whether the score distribution followed a normal distribution. Parametric tests, such as Student's *t*-test and ANOVA, were used for scores that followed a normal distribution and had equal variances, as determined by the Levene test. The variables concerned are FCSRT-Fr Free

https://doi.org/10.1017/S1355617724000390

Table 8. DMS-48: results (percentile, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ –	Educ +	Educ –	Educ +	Total		*p*	
Encoding Time	p5	102	147	126	149	130	**Educ – vs Educ +**		
	p10	140	160	134	165	149	Male	.419	
	p25	170	180	180	197	180	Female	.987	
	p50	**237**	**216**	**233**	**240**	**234**	Whole group	.684	
	p75	322	280	281	308	288	**Male vs Female**		
	p90	389	302	292	325	337	Educ –	.943	
	p95	439	303	360	355	374	Educ +	.369	
	Mean	*243.80*	*232.48*	*235.48*	*246.07*	*239.87*	Whole group	.667	
	(SD)	*(101.70)*	*(67.76)*	*(80.41)*	*(64.41)*	*(79.88)*			
Immediate Recognition Score	p5	35	40	38	40	38	**Educ – vs Educ +**		
	p10	38	40	40	42	40	Male	.052	
	p25	42	44	42	44	43	Female	**.038***	**Educ – < Educ +**
	p50	**45**	**46**	**45**	**46**	**46**	Whole group	**.004****	**Educ – < Educ +**
	p75	46	47	46	47	47	**Male vs Female**		
	p90–p95	47	48	47	48	48	Educ –	.733	
	Mean	*43.47*	*45.16*	*43.57*	*45.33*	*44.37*	Educ +	.905	
	(SD)	*(3.68)*	*(2.98)*	*(4.13)*	*(2.42)*	*(3.42)*	Whole group	.656	
Immediate Recognition Time	p5	80	120	120	122	120	**Educ – vs Educ +**		
	p10	137	120	126	140	126	Male	.104	
	p25	169	140	149	147	145	Female	.283	
	p50	**206**	**185**	**209**	**178**	**200**	Whole group	**.048**	**Educ – > Educ +**
	p75	275	234	298	222	240	**Male vs Female**		
	p90	300	290	312	236	298	Educ –	.854	
	p95	306	331	380	251	312	Educ +	.492	
	Mean	*210.33*	*215.64*	*225.77*	*182.88*	*207.99*	Whole group	.917	
	(SD)	*(71.19)*	*(134.97)*	*(85.49)*	*(42.37)*	*(88.98)*			
Delayed Recognition Score	p5	36	34	34	35	34	**Educ – vs Educ +**		
	p10	39	36	35	38	37	Male	.196	
	p25	41	43	40	43	42	Female	.121	
	p50	**44**	**46**	**44**	**45**	**45**	Whole group	**.048**	**Educ – < Educ +**
	p75	46	47	46	47	46	**Male vs Female**		
	p90	47	48	46	47	47	Educ –	.531	
	p95	48	48	47	48	48	Educ +	.318	
	Mean	*43.28*	*44.12*	*42.09*	*43.78*	*43.35*	Whole group	.362	
	(SD)	*(3.62)*	*(4.59)*	*(5.16)*	*(4.05)*	*(4.34)*			
Delayed Recognition Time	p5	120	106	114	134	112	**Educ – vs Educ +**		
	p10	123	112	120	135	123	Male	.340	
	p25	150	131	145	143	142	Female	.080	
	p50	**187**	**150**	**176**	**170**	**174**	Whole group	.058	
	p75	216	186	240	193	209	**Male vs Female**		
	p90	276	215	300	227	272	Educ –	.854	
	p95	285	294	320	266	300	Educ +	.492	
	Mean	*193.03*	*166.56*	*195.09*	*173.85*	*182.14*	Whole group	.917	
	(SD)	*(62.41)*	*(52.61)*	*(66.82)*	*(44.51)*	*(57.49)*			

Table 9. RCFT - Copy: results (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ –	Educ +	Educ –	Educ +	Total		*p*	
Copy Time	p5	123	105	97	98	98	**Educ – vs Educ +**		
	p10	133	116	116	106	111	Male	**.009****	**Educ – > Educ +**
	p25	194	150	177	117	152	Female	.176	
	p50	**218**	**199**	**195**	**160**	**194**	Whole group	**.004****	**Educ – > Educ +**
	p75	258	240	256	192	240	**Male vs Female**		
	p90	346	300	300	256	300	Educ –	.361	
	p95	480	338	360	264	360	Educ +	**.043***	**Male < Female**
	Mean	*236.28*	*204.00*	*215.36*	*165.89*	*205.52*	Whole group	**.021***	**Male < Female**
	(SD)	*(100.05)*	*(74.09)*	*(82.72)*	*(64.07)*	*(84.86)*			
Copy Score	p5	25	15	28	28,5	25	**Educ – vs Educ +**		
	p10	25	27	29	29	27	Male	.451	
	p25	28	30	30	31	30	Female	.163	
	p50	**32**	**32**	**33**	**33**	**32**	Whole group	.080	
	p75	33	35	34	35	34	**Male vs Female**		
	p90	34	35	35	36	35	Educ –	.055	
	p95	35	36	35	36	36	Educ +	.297	
	Mean	*30.38*	*30.64*	*32.11*	*32.78*	*31.44*	Whole group	**.025***	**Male > Female**
	(SD)	*(3.35)*	*(6.29)*	*(2.92)*	*(2.57)*	*(4.11)*			

https://doi.org/10.1017/S1355617724000390

Table 10. RCFT - Recall: results (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		p	
Immediate Recall Time	p5	38	52	67	47	47	**Educ − vs Educ +**		
	p10	67	63	70	68	67	Male	.750	
	p25	112	103	120	101	110	Female	.826	
	p50	**132**	**163**	**155**	**133**	**141**	Whole group	.946	
	p75	174	187	188	197	188	**Male vs Female**		
	p90	228	225	230	220	226	Educ −	.506	
	p95	252	226	240	333	249	Educ +	.967	
	Mean	*142.71*	*146.29*	*151.23*	*154.63*	*148.42*	Whole group	.669	
	(SD)	*(62.57)*	*(59.64)*	*(54.59)*	*(86.62)*	*(66.17)*			
Immediate Recall Score	p5	3	3	8	7	3	**Educ − vs Educ +**		
	p10	3	4	8	7	5	Male	.117	
	p25	7	7	9	14	9	Female	.276	
	p50	**11**	**13**	**13**	**19**	13	Whole group	**.044***	**Educ − < Educ +**
	p75	15	15	19	20	19	**Male vs Female**		
	p90	18	20	22	23	21	Educ −	**.022***	**Male > Female**
	p95	21	25	23	26	23	Educ +	**.009****	**Male > Female**
	Mean	*10.50*	*12.32*	*14.32*	*17.10*	*13.48*	Whole group	**.0004*****	**Male > Female**
	(SD)	*(5.35)*	*(6.67)*	*(6.05)*	*(5.95)*	*(6.43)*			
Delayed Recall Time	p5	40	47	42	58	42	**Educ − vs Educ +**		
	p10	40	47	59	64	47	Male	.441	
	p25	50	65	68	88	68	Female	.560	
	p50	**107**	**103**	**100**	**119**	**109**	Whole group	.382	
	p75	142	160	135	130	140	**Male vs Female**		
	p90	172	220	160	154	172	Educ −	1.000	
	p95	173	238	170	160	190	Educ +	.916	
	Mean	*102.79*	*118.95*	*101.89*	*110.73*	*108.69*	Whole group	.875	
	(SD)	*(51.32)*	*(68.48)*	*(39.17)*	*(33.64)*	*(49.95)*			
Delayed Recall Score	p5	1	5	2	9	2	**Educ − vs Educ +**		
	p10	2	5	5	11	5	Male	**.040***	**Educ − < Educ +**
	p25	5	7	9	13	9	Female	.199	
	p50	**10**	**12**	**13**	**18**	**13**	Whole group	**.018***	**Educ − < Educ +**
	p75	13	15	18	20	18	**Male vs Female**		
	p90	19	20	21	23	20	Educ −	.057	
	p95	20	20	26	24	23	Educ +	**.005****	**Male > Female**
	Mean	*9.83*	*12.15*	*13.47*	*17.24*	*13.11*	Whole group	**.0007*****	**Male > Female**
	(SD)	*(5.95)*	*(6.33)*	*(6.18)*	*(5.32)*	*(6.47)*			

Recalls, Semantic Fluency, Digit Span Total Score, RCFT Immediate Recall and Delayed Recall Scores and Coding Score. For variables with non-normal distributions, non-parametric tests (Mann Whitney test) were used. Effect sizes were calculated using Cohen's d for parametric tests and biserial rank correlation for non-parametric tests.

Percentile scores (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th}) were provided for each test, stratified by gender and education, as the majority of distributions did not follow a normal distribution.

Tables 3 to 15 present the results for each test of the studied subgroups including the number of participants, percentiles 5 to 95, mean, and standard deviation, as well as the comparison of the four subgroups by gender and/or education.

We also included comparisons between subgroups based on gender and education level. Significant levels (p-values) are reported as follows: * for $p \leq .05$, ** for $p \leq .01$, and *** for $p \leq .001$ when the performance of the subgroups was significantly different.

Results

Global cognitive functions

Table 4 shows that the mean MMSE score for the whole group was 27.36 ($SD = 1.85$), with poorer performance for participants with lower level of education for both women ($U\,(56) = 190$, $p = < .001$, $r_{rb} = .51$) and men ($U\,(51) = 213$, $p = .034$, $r_{rb} = .34$), as well as for the whole group ($U\,(107) = 807$, $p = < .001$, $r_{rb} = .44$). No gender effect was observed.

Language

The mean score on the DO 80 naming test for the whole group was 78.13 ($SD = 4.67$), with no significant differences observed according to gender and education (see Table 5).

Memory

The mean scores for the entire group on the different subtests of the verbal episodic memory test FCSRT-Fr are presented below (see Tables 6 and 7 for detailed scores): immediate recall ($M = 15.07$, $SD = 1.36$), free recalls ($M = 22.86$, $SD = 6.81$), total recalls ($M = 43.95$, $SD = 4.91$), recognition ($M = 15.68$, $SD = 0.75$), delayed free recall ($M = 9.07$, $SD = 3.14$) and total delayed recall ($M = 15.09$, $SD = 2.01$). The study found that participants with lower educational levels performed worse in both free and total recall tasks for the whole group ($t\,(102) = 2.78$, $p = .007$, $d = .54$; $U\,(104) = 914.5$, $p = .004$, $r_{rb} = .32$), as well as for the subgroups of men ($t\,(48) = 2.07$, $p = .04$, $d = .59$; $U\,(50) = 165$, $p = .005$, $r_{rb} = .47$), and women ($t\,(52) = 2.27$, $p = .03$, $d = .62$). No significant interaction between age and education level was observed.

https://doi.org/10.1017/S1355617724000390

Table 11. Verbal Fluency Tests: results (mean, SD, percentiles) and effects of education and gender

			Female		Male			Group comparison		
			Educ −	Educ +	Educ −	Educ +	Total		*p*	
Literal Fluency	**Number of items**	p5	8	13	6	8	8	**Educ − vs Educ +**		
		p10	11	14	8	12	10	Male	**.024***	**Educ − < Educ +**
		p25	13	16	11	16	14	Female	.081	
		p50	**17**	**19**	**15**	**19**	**17**	Whole group	**.008****	**Educ − < Educ +**
		p75	21	24	19	22	21	**Male vs Female**		
		p90	24	32	20	25	25	Educ −	.116	
		p95	28	35	23	31	29	Educ +	.436	
		Mean	*17.13*	*20.76*	*14.67*	*18.81*	*17.85*	Whole group	.151	
		(SD)	*(5.87)*	*(7.25)*	*(5.00)*	*(6.96)*	*(6.60)*			
	Repetitions	**p5–p50**	**0**	**0**	**0**	**0**	**0**			
		p75	0	0	0	1	1			
		p90	1	1	1	2	1			
		p95	1	1	1	3	1			
	Intrusions	**p5–p50**	**0**	**0**	**0**	**0**	**0**			
		p75	0	1	1	1	1			
		p90	1	2	2	3	2			
		p95	1	2	2	3	2			
Semantic Fluency	**Number of items**	p5	9	15	10	14	10	**Educ − vs Educ +**		
		p10	12	16	13	15	13	Male	.077	
		p25	16	19	16	17	17	Female	**.049***	**Educ − < Educ +**
		p50	**21**	**24**	**19**	**22**	**21**	Whole group	**.009****	**Educ − < Educ +**
		p75	25	27	25	28	26	**Male vs Female**		
		p90	28	29	30	33	29	Educ −	.759	
		p95	29	29	32	42	32	Educ +	.819	
		Mean	*20.10*	*23.08*	*19.54*	*23.52*	*21.53*	Whole group	.870	
		(SD)	*(5.95)*	*(4.94)*	*(7.38)*	*(8.23)*	*(6.86)*			
	Repetitions	p5–p25	0	0	0	0	0			
		p50	**0**	**0**	**0**	**1**	**0**			
		p75	1	1	1	1	1			
		p90	2	2	2	2	2			
		p95	2	2	2	3	2			
	Intrusions	**p5–p75**	**0**	**0**	**0**	**0**	0			
		p90	1	0	0	1	1			
		p95	1	0	1	1	1			

The study found a gender effect in the different recall phases for the whole group, with women performing better than men overall. This effect was observed in immediate recall (U (106) = 940, $p = .001$, $r_{rb} = .33$), free recalls (t (102) = 2.44, $p = .016$, $d = .48$), total recalls (U (104) = 1005, $p = .024$, $r_{rb} = .26$), delayed free recall (U (103) = 979, $p = .022$, $r_{rb} = .26$) and total delayed recall (U (103) = 984, $p = .011$, $r_{rb} = .26$). Furthermore, the study found that participants with a lower level of education had lower scores in immediate recall (U (54) = 208, $p = .005$, $r_{rb} = .42$), total recalls (U (52) = 208, $p = .020$, $r_{rb} = .38$), and delayed total recalls (U (51) = 202, $p = .011$, $r_{rb} = .37$).

Intrusions after cueing are rare (median between subgroups from 0 to 1). Similarly, false recognitions in the recognition task were rare, with most subjects in the different subgroups making no such errors (see Appendix 2 for details).

The DMS-48 visual memory test results for the entire group (see Table 8), showed two mean scores: immediate recognition score ($M = 44.37$, $SD = 3.42$) and delayed recognition score ($M = 43.35$, $SD = 4.34$). Test completion times were also recorded and analyzed. No gender effect was observed on any of the measures (score and time to completion). Regarding the effect of education on completion times, a difference was only found for the immediate recognition subtest among the whole group (U (103) = 1026, $p = .048$, $r_{rb} = .23$), with subjects with lower level of education performing slower.

Subjects with a lower level of education performed worse on both immediate and delayed recognition scores (respectively, for the whole group, U (105) = 932, $p = .004$, $r_{rb} = .32$ and U (104) = 1047, $p = .046$, $r_{rb} = .23$).

Visuospatial abilities

As shown in Tables 9 and 10, on the RCFT, the mean scores for copying, immediate recall and delayed recall for the whole group were 31.44 ($SD = 4.11$), 13.48 ($SD = 6.43$), and 13.11 ($SD = 6.47$), respectively. Males performed faster (U (103) = 974, $p = .021$, $r_{rb} = .26$) and more efficiently (U (103) = 984; $p = .025$, $r_{rb} = .26$) than females in copying, and participants with higher education performed faster (U (103) = 887, $p = .004$, $r_{rb} = .33$). There were no observable effects on completion time for either immediate or delayed recall.

Women were less efficient than men for both immediate and delayed recall (t (99) = −3,70, $p = < .001$, $d = -.74$; t (88) = −3,54, $p = < .001$, $d = -.75$). Participants with higher education outperformed those with lower education (t (99) = 2,04, $p = .044$, $d = .41$; t (88) = 2.40; $p = .018$, $d = .51$)

Attention and executive function

Fluency tasks

The group's mean scores for literal fluency and semantic fluency were 17.85 ($SD = 6.60$) and 21.53 ($SD = 6.86$), respectively. There was a group effect of education (U (107) = 1002, $p = .008$, $r_{rb} = .30$) and only for males (U (51) = 204, $p = .024$, $r_{rb} = .37$) on the verbal literal fluency task (see Table 11 for details). Participants

https://doi.org/10.1017/S1355617724000390

Table 12. STROOP Test: results for time (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		p	
Naming	p5	59	55	60	60	58	**Educ − vs Educ +**		
	p10	59	59	62	60	60	Male	.771	
	p25	67	61	66	68	67	Female	.317	
	p50	**78**	**72**	**75**	**74**	**75**	Whole group	.274	
	p75	90	90	100	81	89	**Male vs Female**		
	p90	100	95	130	90	100	Educ −	.903	
	p95	100	96	165	92	109	Educ +	.823	
	Mean	*78.81*	*75.00*	*85.55*	*75.70*	*78.43*	Whole group	.950	
	(SD)	*(15.01)*	*(14.83)*	*(31.36)*	*(12.82)*	*(19.17)*			
Reading	p5	45	42	39	40	41	**Educ − vs Educ +**		
	p10	45	42	44	41	42	Male	.156	
	p25	49	44	48	44	46	Female	.237	
	p50	**52**	**51**	**52**	**49**	**51**	Whole group	.062	
	p75	60	55	55	52	55	**Male vs Female**		
	p90	63	65	67	63	63	Educ −	.833	
	p95	81	71	72	64	73	Educ +	.579	
	Mean	*54.69*	*51.48*	*52.90*	*50.19*	*52.28*	Whole group	.429	
	(SD)	*(10.38)*	*(8.95)*	*(8.90)*	*(8.66)*	*(9.29)*			
Interference	p5	121	108	96	118	108	**Educ − vs Educ +**		
	p10	124	126	128	119	124	Male	.242	
	p25	160	134	143	135	139	Female	.348	
	p50	**173**	**169**	**158**	**142**	**166**	Whole group	.070	
	p75	203	191	210	175	192	**Male vs Female**		
	p90	245	211	223	201	236	Educ −	.331	
	p95	245	240	420	237	245	Educ +	.381	
	Mean	*183.36*	*168.13*	*179.47*	*157.22*	*171.34*	Whole group	.165	
	(SD)	*(48.01)*	*(43.38)*	*(68.09)*	*(33.81)*	*(48.68)*			
Interference - Naming	p5	54	50	34	43	40	**Educ − vs Educ +**		
	p10	61	53	40	45	53	Male	.647	
	p25	89	66	62	59	65	Female	.227	
	p50	**98**	**90**	**75**	**79**	**89**	Whole group	.128	
	p75	120	121	102	95	109	**Male vs Female**		
	p90	155	145	162	141	151	Educ −	.072	
	p95	155	151	320	164	164	Educ +	.206	
	Mean	*106.08*	*93.13*	*95.16*	*81.52*	*93.65*	Whole group	**.020***	**Male < Female**
	(SD)	*(40.13)*	*(42.11)*	*(63.29)*	*(34.09)*	*(44.94)*			

with lower level of education, especially men, produced fewer words beginning with the letter P. Most participants did not have any intrusions or item repetitions, with a median of 0 for both variables, regardless of gender or level of education.

In the semantic verbal fluency task, participants with lower education produced fewer animal words (t (105) = 2.68, p = .009, d = .52), and this effect was only observed in the female subgroup (t (54) = 2.01, p = .049, d = .54). No intrusions or item repetitions were found for most participants (with a median of 0 for these two variables).

No gender effect was found for the either test, for the whole group or when considering education.

Stroop test

The mean scores for naming, reading, and interference tasks for the entire group were 78.43 (SD = 19.17), 52.28 (SD = 9.29), and 171.34 (SD = 48.68), respectively. Table 12 shows that there were few significant differences between the subgroups, regardless of the variable studied (gender or education level). Nevertheless, the difference in execution times between the interference task and the naming task was more pronounced for women than men, regardless of their level of education (U (94) = 797, p = .020, r_{rb} = .28).

The majority of participants did not make any errors in the naming and reading subtest, while in the interference subtest, most participants made zero or one error (see Appendix 3).

Trail making test

Participants with lower levels of education completed Part A (M = 62.73, DS = 21.28 for the whole group) and Part B (M = 169.68, SD = 70.39 for the whole group) more slowly (U (102) = 896, p = .007, r_{rb} = .31; U (95) = 769, p = .008, r_{rb} = .32 respectively). This effect of educational level was not found for Part A when considering the male and female subgroups separately. For Part B, it was found only for the female subgroup (U (48) = 158, p = .008, r_{rb} = .45). Similarly, when looking at the difference in time between the two parts, a longer time to completion was found for women with lower level of education (U (48) = 165, p = .011, r_{rb} = .43).

No significant differences were found between the two male subgroups based on their level of education.

Part A had a low error rate, with 93% of participants making no errors. In Part B, participants with a higher level of education demonstrated an average of 0.7 errors with 57% making no errors. In contrast, those with a lower level of education made an average of 1.4 errors, with only 38% making no errors.

Detailed results are given in Table 13.

Digit span

The total mean score for the entire group was 20.69 (SD = 4.48). No significant differences were found between the subgroups based on gender or education for the Digit Span Forward and Sequencing Digit Span memory tasks in either scores or span (see Table 14 for

https://doi.org/10.1017/S1355617724000390

Table 13. TMT: results (percentiles, mean, SD) and effects of education and gender

			Female		Male			Group comparison		
			Educ −	Educ +	Educ −	Educ +	Total		*p*	
TMT A	**Time**	p5	47	41	37	35	36	**Educ − vs Educ +**		
		p10	48	42	38	35	38	Male	.059	
		p25	55	47	51	38	48	Female	.056	
		p50	**62**	**54**	**63**	**55**	**57**	Whole group	**.007****	**Educ − > Educ +**
		p75	79	70	76	64	75	**Male vs Female**		
		p90	103	75	90	95	97	Educ −	.849	
		p95	104	96	120	112	104	Educ +	.345	
		Mean	*69.00*	*58.83*	*66.68*	*56.22*	*62.73*	Whole group	.331	
		(SD)	*(21.38)*	*(16.33)*	*(23.35)*	*(21.81)*	*(21.28)*			
	Errors	**p5–90**	**0**	**0**	**0**	**0**	**0**			
		p95	1	1	1	0	1			
TMT B	**Time**	p5	96	97	84	75	88	**Educ − vs Educ +**		
		p10	112	98	93	85	96	Male	.344	
		p25	156	118	110	106	120	Female	**.008****	**Educ − > Educ +**
		p50	**188**	**138**	**156**	**148**	**149**	Whole group	**.008****	**Educ − > Educ +**
		p75	274	162	219	181	199	**Male vs Female**		
		p90	306	251	259	216	274	Educ −	.089	
		p95	329	277	294	221	306	Educ +	.930	
		Mean	*209.16*	*156.00*	*167.90*	*146.11*	*169.68*	Whole group	.120	
		(SD)	*(84.15)*	*(6.89)*	*(69.11)*	*(45.60)*	*(70.39)*			
	Errors	p5–25	0	0	0	0	0			
		p50	**2**	**0**	1	0	0			
		p75	3	1	2	1	1			
		p90	4	1	3	2	2			
		p95	5	2	4	3	3			
TMT B-A	**Time**	p5	45	44	30	32	39	**Educ − vs Educ +**		
		p10	50	45	36	39	43	Male	.699	
		p25	90	61	55	61	64	Female	**.011***	**Educ − > Educ +**
		p50	**123**	**85**	**89**	**90**	**93**	Whole group	**.029***	**Educ − > Educ +**
		p75	185	118	157	116	140	**Male vs Female**		
		p90	234	176	177	149	180	Educ −	.087	
		p95	250	178	216	152	234	Educ +	.922	
		Mean	*141.40*	*98.78*	*104.00*	*89.89*	*108.57*	Whole group	.110	
		(SD)	*(75.80)*	*(60.48)*	*(61.84)*	*(36.91)*	*(62.35)*			

scores and Appendix 4 for span). Participants with a higher level of education, particularly women, performed significantly better, on two subtests. The Digit Span Backward subtest showed significant results for the entire group ($U(106) = 1019$, $p = .013$, $r_{rb} = .27$) and for the women subgroup ($U\ (55) = 248$, $p = .030$, $r_{rb} = .34$). Additionally, the Total Score also showed consistent results for the entire group ($t\ (104) = 2.54$, $p = .012$) and for the women subgroup ($U\ (55) = 215$, $p = .007$, $r_{rb} = .43$).

Speed of processing

The Coding test performance ($M = 39.03$; $SD = 11.35$ for the whole group) was significantly better for participants with higher level of education compared to those with lower level of education ($U\ (103) = 795$, $p\ = < .001$, $r_{rb} = .40$), and this was true for both males ($U\ (50) = 199$, $p = .031$, $r_{rb} = .36$) and females ($t\ (51) = 3.03$, $p = .004$, $d = .84$). No significant differences were found between the performance of men and women, regardless of their level of education (see Table 15 for details). Coding errors were rare, with no errors for 79% of the subjects and only one error for 11%.

Gestural praxis

The whole group performed well on the following three subtests, as shown in Table 16: Symbolic Gestures ($M = 4.71$, $SD = 0.58$), Action Mimes ($M = 9.38$, $SD = 0.99$) and Meaningless Gestures ($M = 7.28$, $SD = 1.04$). No significant differences were found between the different subgroups on the Symbolic and Meaningless Gestures subtests. On the Action Mimes subtest, women performed slightly worse than men ($U\ (107) = 1020$; $p = .003$, $r_{rb} = .29$). This trend was only found for participants with a higher level of education ($U\ (52) = 223$, $p = .010$, $r_{rb} = .34$).

Discussion

The aim of this study was to provide updated norms, adapted to the oldest old people, for neuropsychological tests frequently used by French clinicians, in conditions close to the classical clinical assessment. We found that although some studies had developed norms for the old French population, the tests were not always adapted to the oldest old individuals (Roussel & Godefroy, 2008), nor for the general population (Peres et al., 2012), or were no longer used in clinical practice (Giulioli et al., 2016).

Our study assessed various domains by administering tests, commonly used in current clinical practice in France. We analyzed the impact of gender and education on each test by dividing the participants into four subgroups based on these variables. The majority of the tests demonstrated significant differences in performance depending on gender and/or level of education, confirming the importance of these two factors in establishing normative data. Furthermore, the distinction between two levels of

Table 14. Digit Span: results (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		*p*	
Digit Span Forward	p5	4	5	5	6	5	**Educ − vs Educ +**		
	p10	5	5	5	6	5	Male	.692	
	p25	5	6	6	6	6	Female	.083	
	p50	**7**	**8**	**7**	**8**	**7**	Whole group	.099	
	p75	8	10	9	9	9	**Male vs Female**		
	p90	10	10	10	10	10	Educ −	.146	
	p95	11	12	12	11	12	Educ +	.927	
	Mean	*6.90*	*7.92*	*7.79*	*7.93*	*7.60*	Whole group	.204	
	(SD)	*(2.07)*	*(2.12)*	*(2.13)*	*(1.80)*	*(2.05)*			
Digit Span Backward	p5	4	5	4	4	4	**Educ − vs Educ +**		
	p10	4	6	4	4	4	Male	.187	
	p25	4	6	5	6	5	Female	**.032***	**Educ − < Educ +**
	p50	**6**	**7**	**6**	**6**	**7**	Whole group	**.015***	**Educ − < Educ +**
	p75	8	8	7	8	8	**Male vs Female**		
	p90	8	9	8	9	9	Educ −	.728	
	p95	10	9	8	9	9	Educ +	.097	
	Mean	*6.27*	*7.28*	*6.00*	*6.59*	*6.53*	Whole group	.203	
	(SD)	*(1.91)*	*(1.43)*	*(1.44)*	*(1.53)*	*(1.65)*			
Sequencing Digit Span	p5	2	4	4	4	4	**Educ − vs Educ +**		
	p10	3,5	4	5	4	4	Male	.503	
	p25	4	6	6	6	5	Female	.064	
	p50	**6**	**7**	**6**	**7**	**6**	Whole group	.050	
	p75	7	8	8	9	8	**Male vs Female**		
	p90	9	9	9	9	9	Educ −	.161	
	p95	9	9	10	11	9	Educ +	.920	
	Mean	*5.80*	*6.84*	*6.67*	*7.04*	*6.56*	Whole group	.240	
	(SD)	*(2.23)*	*(1.91)*	*(2.06)*	*(1.95)*	*(2.08)*			
Digit Span Total Score	p5	12	15	14	15	13	**Educ − vs Educ +**		
	p10	12	16	16	16	15	Male	.338	
	p25	15	20	18	18	18	Female	**.018***	**Educ − < Educ +**
	p50	**19**	**22**	**21**	**22**	**21**	Whole group	**.012***	**Educ − < Educ +**
	p75	22	24	23	24	23	**Male vs Female**		
	p90	24	26	25	28	26	Educ −	.254	
	p95	31	28	27	28	28	Educ+	.663	
	Mean	*18.97*	*22.04*	*20.46*	*21.56*	*20.69*	Whole group	.441	
	(SD)	*(5.32)*	*(3.71)*	*(3.83)*	*(4.22)*	*(4.48)*			

Table 15. Coding: results (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		*p*	
Score	p5	17	27	22	26	21	**Educ − vs Educ +**		
	p10	21	28	23	29	26	Male	**.025***	**Educ − < Educ +**
	p25	27	40	27	36	29	Female	**.004****	**Educ − < Educ +**
	p50	**32**	**45**	**36**	**42**	**41**	Whole group	**.0002*****	**Educ − < Educ +**
	p75	45	50	44	48	47	**Male vs Female**		
	p90	47	58	50	56	53	Educ −	.689	
	p95	51	58	56	57	58	Educ +	.466	
	Mean	*34 .45*	*44.13*	*35.78*	*42.19*	*39.03*	Whole group	.856	
	(SD)	*(12.66)*	*(10.08)*	*(10.80)*	*(8.77)*	*(11.35)*			
Errors	**p5–p50**	**0**	**0**	**0**	**0**	**0**			
	p75	0	0	1	0	0			
	p90	1	2	1	2	2			
	p95	4	2	2	2	2			

education (primary school level vs. secondary school level) seems to be relevant for the majority of the tests. The study found that participants with a lower level of education scored lower or completed tests more slowly than their more educated peers, confirming previous studies showing an effect of education level on cognitive performance in aging (Fletcher et al., 2021; Grasset et al., 2018; Opdebeeck et al., 2015). The observed differences between genders were minimal. Women outperformed men in verbal episodic memory while men performed better on praxis and visual construction tasks, which is consistent with previous studies (McCarrey et al., 2016; Munro et al., 2012; Proust-Lima et al., 2008) but no gender effect was observed on other tests. As the majority of participants were aged between 82 and 84, it was not possible to conduct a subgroup analysis that included age, in addition to gender, and level of education. However, we analyzed the correlation between age and performance for each subgroup, divided by gender and level of education, to determine if age had an impact on performance on the subtests. The significant correlations are presented in Table 17. An

https://doi.org/10.1017/S1355617724000390

Table 16. MLB: results (percentiles, mean, SD) and effects of education and gender

		Female		Male			Group comparison		
		Educ −	Educ +	Educ −	Educ +	Total		*p*	
Symbolic Gestures	p5	3	4	4	4	4	**Educ − vs Educ +**		
	p10	4	4	4	4	4	Male	.401	
	p25	4	4	5	5	4	Female	.773	
	p50–p95	**5**	**5**	**5**	**5**	**5**	Whole group	.656	
							Male vs Female		
							Educ −	.728	
	Mean	*4.58*	*4.64*	*4.75*	*4.89*	*4.71*	Educ +	.126	
	SD	*0.85*	*0.49*	*0.44*	*0.32*	*0.58*	Whole group	.179	
Action Mimes	p5	6	8	8	8	8	**Educ − vs Educ +**		
	p10	7	8	8	9	8	Male	.396	
	p25	8	8	9	10	9	Female	.928	
	p50–p95	**10**	**10**	**10**	**10**	**10**	Whole group	.411	
							Male vs Female		
							Educ −	.161	
	Mean	*9.06*	*9.16*	*9.58*	*9.78*	*9.38*	Educ +	**.036***	**Male > Female**
	SD	*1.24*	*1.07*	*0.72*	*0.58*	*0.99*	Whole group	**.011***	**Male > Female**
Meaningless Gestures	p5	5	5	6	6	5	**Educ − vs Educ +**		
	p10	5	6	6	6	6	Male	.977	
	p25	6	7	7	7	7	Female	.993	
	p50–p95	**8**	**8**	**8**	**8**	**8**	Whole group	.957	
							Male vs Female		
							Educ −	.656	
	Mean	*7.13*	*7.29*	*7.39*	*7.33*	*7.28*	Educ +	.657	
	SD	*1.23*	*0.91*	*0.84*	*1.11*	*1.04*	Whole group	.544	

Table 17. Correlation between age and subtest performance using Spearman's correlation test for each subgroup

	Female		Male	
	Educ −	Educ +	Educ −	Educ +
Age - MMSE		−.48*	−.48*	
Age - DO 80		−.41*		
Age - FCSRT-FR Immediate Recall				−.53**
Age - FCSRT-FR Free Recalls				−.48*
Age - FCSRT-FR Delayed Free Recall				−.45*
Age - DMS-48 Immediate Recognition Score		−.40*		
Age - DMS-48 Immediate Recognition Time				.40*
Age - DMS-48 Delayed Recognition Score		−.53**		
Age - RCFT Copy Time		.52**	−.43*	
Age - Verbal Literal Fluency (P) Number of items	.39*			
Age - TMT B Time		.42*		
Age - Coding Score		−.41*		
Age - MLB Action Mimes				−.41*
Age - MLB Meaningless Gestures		−.43*		

Note. * $p < .05$, ** $p < .01$, *** $p < .001$.

age-related effect was observed mainly in the groups of men and women with higher level of education, particularly on certain episodic memory subtests. The results suggest that participants with a higher level of education may experience a moderate effect on their success in certain tests or the time taken to complete them as they age.

In the study, the Wilcoxon one-sample *t*-test was used to compare the performance of the participants with the theoretical averages derived from existing standards in the elderly population. The participants' performance was similar to existing standards in the domains of verbal literal fluency (Roussel & Godefroy, 2008), visual episodic memory (Barbeau et al., 2004), and praxis (Mahieux-Laurent et al., 2009). However, there seemed to be a strong ceiling effect for the proposed tests in the last two domains. This effect could mask differences when controlling for variables such as gender or level of education. Verbal episodic memory performance, on the other hand, was below the norms of Van der Linden et al. (2004), probably due to the wider age range (over 74 vs. over 82 in our study). Additionally, differences were found in executive functions. Specifically, the FIBRATLAS cohort performed worse on the verbal semantic fluency task compared to results of Roussel and Godefroy (2008) or Cardebat et al. (1990). Additionally, our cohort exhibited slower performance on complex tasks, compared to the established norms in previous studies. This could be attributed to the fact that existing norms are based on a population with a wider age range, such as the group of people individuals over 60 in GREFEX. Differences between our study and previous ones were observed through a qualitative analysis, particularly in relation to the pathological thresholds corresponding to the tenth percentile. Our study population had higher thresholds than in those of similar age groups in the studies conducted by Amieva et al. (2007), Kalafat et al. (2003), and

https://doi.org/10.1017/S1355617724000390

Ferreira et al. (2010) in terms of global cognitive functions and episodic memory retrieval process.

If we compare the standards established in our study with the four subgroups defined by gender and educational level, we still find some differences with previous studies. To illustrate, we can consider the performance of an 86-year-old male with a primary school education and a score on the FCSRT-Fr, as predicted by the regression equation proposed in the French Princeps study (Van der Linden et al., 2004). It would yield an expected free recalls score would of 32/48. In contrast, our study yielded a score of 20.58. If we consider the standards and the same groups as those presented by Amieva et al. (2007), the expected score for free recalls is 17/48, while in our cohort it is 22. Another illustrative example is the RCFT, with the same imaginary case. The mean expected score on the copy task is 30/36 in accordance with the standards of Fastenau et al. (1999), while in our study it is 33/36. However, the cutoff score (−2 *DS*) is 27.64/36 for Fastenau et al. (1999), whereas it is 21.1/36 in our cohort.

This study has several strengths. Firstly, we propose tests to assess a wide range of cognitive functions commonly tested in older people under assessment conditions close to clinical practice. In addition, we provide detailed normative information in percentiles, controlling for gender and educational level. We have also emphasized the importance of using normative data for a more restricted age range in older age.

However, it is important to acknowledge the limitations of our study. The sample size was relatively small, with only 107 participants. Furthermore, the uneven age distribution of the participants, with 82.2% of the population aged between 82 and 87, prevented the creation of subgroups based on age, gender, and education. Providing information on the participants' socioeconomic status, in addition to their educational background, would have offered valuable insights, as recently suggested by Migeot et al. (2022). Additionally, the profile of the participants in the FIBRATLAS cohort who chose to donate their bodies after death may limit the study. These individuals may be particularly concerned about the importance of medical and scientific research. Therefore, they may not be representative of the general population.

Regarding the tests, only a few scores were found to follow a normal distribution: free recalls for the FCSRT-Fr, semantic verbal fluency, digit span total score, immediate recall, and delayed recall for the RCFT, and coding score. Ceiling effects were observed for some of the subcomponents of five tests, indicating a lack of sensitivity. These tests include the DO 80, with a median score close to the maximum score and a high cutoff score; the FCSRT-Fr for immediate recall, total recalls, recognition, and delayed total recalls; the MLB and DMS-48 for all the subtests. The use of normative data in percentiles is therefore necessary in clinical practice.

Our study focused on assessing memory, processing speed, and executive functions, which are typically affected by cognitive aging. A more detailed assessment of language could be proposed, focusing on mnemonic and executive components including comprehension of complex instructions, sentence concatenation, rapid naming, and sentence repetition.

In conclusion, this study aims to contribute to the development of norms for the oldest old population based on gender and level of education. The study focuses on tests commonly used in clinical practice in France, under conditions similar to those of a neuropsychological assessment. However, caution must be exercised when interpreting the results, especially for subjects aged over 90, due to the small size of the subgroups and the uneven age distribution of the participants. Establishing reliable norms would be valuable by generalizing these results to a larger population of oldest old and comparing them with young-old adults.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S1355617724000390

Acknowledgements. The authors do not have any conflicts of interest to declare. This work was supported by the National Research Agency (ANR-14-CE17-0015). The data used in this article were provided by the FIBRATLAS project. The researchers listed in the FIBRATLAS consortium (see full list with affiliations in the supplementary material) designed and implemented the FIBRATLAS project and/or provided data, but not all were involved in the analysis or writing of this manuscript.

The authors thank the participants and the testers of the FIBRATLAS Project.

References

Amieva, H., Carcaillon, L., Rouze L'Alzit-Schuermans, P., Millet, X., Dartigues, J. F., Fabrigoule, C. (2007). Test de rappel libre/rappel indicé à 16 items: Normes en population générale chez des sujets âgés issues de l'étude des 3 cités. *Revue Neurologique*, *163*(2), 205–221. https://doi.org/10.1016/S0035-3787(07)90392-6

Angel, L., & Isingrini, M. (2015). Le vieillissement neurocognitif : Entre pertes et compensation. *L'Année Psychologique*, *115*(02), 289–324. https://doi.org/10.4074/S0003503314000104

Barbeau, E., Didic, M., Tramoni, E., Felician, O., Joubert, S., Sontheimer, A., Ceccaldi, M., Poncet, M. (2004). Evaluation of visual recognition memory in MCI patients. *Neurology*, *62*(8), 1317–1322. https://doi.org/10.1212/01.WNL.0000120548.24298.DB

Braver, T. S., & West, R. (2008). Working memory, executive control, and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 331–398). New York: Psychology Press.

Cabeza, R., Nyberg, L., & Park, D. C. Eds (2016). *Cognitive neuroscience of aging: Linking cognitive and cerebral aging*. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199372935.001.0001

Cardebat, D., Doyon, B., Puel, M., Goulet, P., & Joanette, Y. (1990). Formal and semantic lexical evocation in normal subjects. Performance and dynamics of production as a function of gender, age and educational level. *Acta neurologica Belgica*, *90*(4), 207–217.

Deloche, G., & Hannequin, D. (1997). *DO 80 – Epreuve de dénomination orale d'images*. Paris: ECPA par Pearson.

Eurostat. Population by age group [Data file] (2022). https://ec.europa.eu/eurostat/databrowser/view/TPS00010/bookmark/table?lang=en&bookmarkId=3c9ab56f-8582-462c-bbdd-a0ccceb3aeac.

Fastenau, P. S., Denburg, N. L., & Hufford, B. J. (1999). Adult norms for the rey-osterrieth complex figure test and for supplemental recognition and matching trials from the extended complex figure test. *The Clinical Neuropsychologist*, *13*(1), 30–47. https://doi.org/10.1076/clin.13.1.30.1976

Ferreira, S., Vanholsbeeck, G., Chopard, G., Pitard, A., Tio, G., Vandel, P., Galmiche, J., Rumbach, L. (2010). Normes comparatives de la batterie de tests neuropsychologiques RAPID pour les sujets âgés de 50 à 89 ans. *Revue Neurologique*, *166*(6-7), 606–614. https://doi.org/10.1016/j.neurol.2009.12.005

Fletcher, J., Topping, M., Zheng, F., & Lu, Q. (2021). The effects of education on cognition in older age: Evidence from genotyped siblings. *Social Science & Medicine*, *280*, 114044. https://doi.org/10.1016/j.socscimed.2021.114044

Gil, R. (2018). Neuropsychologie (7e éd). Paris: Elsevier Masson.

Giulioli, C., & Amieva, H. (2016). Évaluation neuropsychologique des sujets très âgés ou oldest old: Problématiques et enjeux. *Revue de neuropsychologie*, *8*(3), 158. https://doi.org/10.3917/rne.083.0158

Giulioli, C., Meillon, C., Gonzalez-Colaço Harmand, M., Dartigues, J.-F., & Amieva, H. (2016). Normative scores for standard neuropsychological tests in the oldest old from the French population-based PAQUID study. *Archives*

of Clinical Neuropsychology, *31*(1), 58–65. https://doi.org/10.1093/arclin/acv055
Goh, J. O., An, Y., & Resnick, S. M. (2012). Differential trajectories of age-related changes in components of executive and memory processes. *Psychology and Aging*, *27*(3), 707–719.
Grasset, L., Jacqmin-Gadda, H., Proust-Lima, C., Pérès, K., Amieva, H., Dartigues, J.-F., & Helmer, C. (2018). Temporal trends in the level and decline of cognition and disability in an elderly population. *American Journal of Epidemiology*, *187*(10), 2168–2176. https://doi.org/10.1093/aje/kwy118
Hartley, A., Angel, L., Castel, A., Didierjean, A, Geraci, L., Hartley, J., Hazeltine, E., Lemaire, P., Maquestiaux, F., Ruthruff, E., Taconnat, L., Thevenot, C., Touron, D. (2018). Successful aging: The role of cognitive gerontology. *Experimental Aging Research*, *44*(1), 82–93. https://doi.org/10.1080/0361073X.2017.1398849
Kalafat, M., Hugonot-Diener, L., & Poitrenaud, J. (2003). Standardisation et étalonnage français du « Mini Mental State » (MMS) version GRECO [French standardization and range for the GRECO version of the. *Mini Mental State » (MMS)]. Revue de Neuropsychologie*, *13*(2), 209–236.
Levine, D. A., Gross, A. L., Briceño, E. M., Tilton, N., Giordani, B. J., Sussman, J. B., Hayward, R. A., Burke, J. F., Hingtgen, S., Elkind, M. S. V., Manly, J. J., Gottesman, R. F., Gaskin, D. J., Sidney, S., Sacco, R. L., Tom, S. E., Wright, C. B., Yaffe, K., Galecki, A. T. (2021). Sex differences in cognitive decline among us adults. *JAMA Network Open*, *4*(2), e210169. https://doi.org/10.1001/jamanetworkopen.2021.0169
Lövdén, M., Fratiglioni, L., Glymour, M. M., Lindenberger, U., & Tucker-Drob, E. M. (2020). Education and cognitive functioning across the life span. *Psychological Science in the Public Interest*, *21*(1), 6–41. https://doi.org/10.1177/1529100620920576
Mahieux-Laurent, F., Fabre, C., Galbrun, E., Dubrulle, A., & Moroni, C. (2009). Validation d'une batterie brève d'évaluation des praxies gestuelles pour consultation Mémoire. Évaluation chez 419 témoins, 127 patients atteints de troubles cognitifs légers et 320 patients atteints d'une démence. *Revue Neurologique*, *165*(6-7), 560–567. https://doi.org/10.1016/j.neurol.2008.11.016
McCarrey, A. C., An, Y., Kitner-Triolo, M. H., Ferrucci, L., & Resnick, S. M. (2016). Sex differences in cognitive trajectories in clinically normal older adults. *Psychology and Aging*, *31*(2), 166–175. https://doi.org/10.1037/pag0000070
Meulemans, T. (2008). La batterie GREFEX: Présentation générale [GREFEX battery: Overview]. In O. Godefroy, & GREFEX (Eds.), *Fonctions exécutives et pathologies neurologiques et psychiatriques* (pp. 217-229). Marseille: Solal.
Migeot, J., Calivar, M., Granchetti, H., Ibáñez, A., & Fittipaldi, S. (2022). Socioeconomic status impacts cognitive and socioemotional processes in healthy ageing. *Scientific Reports*, *12*(1), 6048. https://doi.org/10.1038/s41598-022-09580-4
Montgomery, S. A., & Asberg, M. (1979). A new depression scale designed to be sensitive to change. *The British Journal of Psychiatry*, *134*(4), 382–389. https://doi.org/10.1192/bjp.134.4.382
Munro, C. A., Winicki, J. M., Schretlen, D. J., Gower, E. W., Turano, K. A., Muñoz, B., Keay, L., Bandeen-Roche, K., West, S. K. (2012). Sex differences in cognition in healthy elderly individuals. *Aging, Neuropsychology, and Cognition*, *19*(6), 759–768. https://doi.org/10.1080/13825585.2012.690366
Opdebeeck, C., Martyr, A., & Clare, L. (2015). Cognitive reserve and cognitive function in healthy older people: A meta-analysis. *Aging, Neuropsychology, and Cognition*, *23*(1), 40–60. https://doi.org/10.1080/13825585.2015.1041450
Park, D. C., & Reuter-Lorenz, P. (2009). The adaptive brain: Aging and neurocognitive scaffolding. *Annual Review of Psychology*, *60*(1), 173–196. https://doi.org/10.1146/annurev.psych.59.103006.093656
Pérès, K., Matharan, F., Allard, M., Amieva, H., Baldi, I., Barberger-Gateau, P., Bergua, V., Bourdel-Marchasson, I., Delcourt, C., Foubert-Samier, A., Fourrier-Réglat, A., Gaimard, M., Laberon, S., Maubaret, C., Postal, V., Chantal, C., Rainfray, M., Rascle, N., Dartigues, J.-F. (2012). Health and aging in elderly farmers: The AMI cohort. *BMC Public Health*, *12*(1), 558. https://doi.org/10.1186/1471-2458-12-558
Proust-Lima, C., Amieva, H., Letenneur, L., Orgogozo, J.-M., Jacqmin-Gadda, H., & Dartigues, J.-F. (2008). Gender and education impact on brain aging: A general cognitive factor approach. *Psychology and Aging*, *23*(3), 608–620. https://doi.org/10.1037/a0012838
Roussel, M., & Godefroy, O. (2008). La batterie GREFEX : données normatives [The Grefex Battery : Normative data]. In O.Godefroy & GREFEX (Eds.), *Fonctions exécutives et pathologies neurologiques et psychiatriques* (pp. 231–252). Marseille:Solal.
Rullier, L., Matharan, F., Barbeau, E. J., Mokri, H., Dartigues, J.-F., Pérès, K., & Amieva, H. (2014). Test du DMS-48 : Normes chez les sujets âgés et propriétés de détection de la maladie d'Alzheimer dans la cohorte AMI [DMS-48: Norms and diagnostic proprieties for Alzheimer's disease in elderly population from the AMI cohort study]. *Gériatrie et Psychologie Neuropsychiatrie du Vieillissement*, *12*(3), 321–330. https://doi.org/10.1684/pnv.2014.0486
Salthouse, T. A. (2019). Trajectories of normal cognitive aging. *Psychology and Aging*, *34*(1), 17–24. https://doi.org/10.1037/pag0000288
Seblova, D., Berggren, R., & Lövdén, M. (2020). Education and age-related decline in cognitive performance: Systematic review and meta-analysis of longitudinal cohort studies. *Ageing Research Reviews*, *58*, 101005. https://doi.org/10.1016/j.arr.2019.101005
Stern, Y. (2002). What is cognitive reserve? Theory and research application of the reserve concept. *Journal of the International Neuropsychological Society*, *8*(3), 448–460. https://doi.org/10.1017/S1355617702813248
Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*(10), 2015–2028. https://doi.org/10.1016/j.neuropsychologia 2009.
The 3C Study Group (2003). Vascular factors and risk of dementia: Design of the three-city study and baseline characteristics of the study population. *Neuroepidemiology*, *22*(6), 316–325. https://doi.org/10.1159/000072920
Van der Linden, M., Coyette, F., Poitrenaud, J., Kalafat, M., Calicis, F., Adam, S., . . . , les membres du GREMEM (2004). L'épreuve de rappel libre / rappel indicé à 16 items (RL/RI-16) [The 16-item free recall/cued recall test (RL/RI-16)]. In M. Van der Linden, S. Adam, A. Agniel, C. Baisset Mouly et les membres du GREMEM (Eds.), *L'évaluation des troubles de la mémoire* (pp. 25–47). Marseille: Solal.
Wechsler, D. (2011). *WAIS-IV - Echelle d'intelligence de Wechsler pour adultes —4ème édition*. Paris:ECPA par Pearson.