Subjective and Objective Memory Performance:

The Impact of Sociodemographics

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Resumo

Introdução: a metamemória refere-se a vários processos metacognitivos que nos permitem pensar sobre a eficácia e a condição da nossa memória, bem como adaptar o nosso desempenho, sendo essencial tanto na aprendizagem como na recordação de informações. As Queixas Subjetivas de Memória (SMC) constituem uma autoavaliação da memória podendo estar ou não estar associadas a défices cognitivos, comprovados através de testes neuropsicológicos. As SMC ocorrem habitualmente em sujeitos mais velhos, com nível académico mais baixo e com sintomatologia depressiva. *Objetivo:* Este estudo pretende investigar se a idade, a educação e o afeto negativo influenciam a avaliação da metamemória e a relação entre as SMC e o desempenho mnésico objetivo. *Resultados:* Os resultados confirmam a influência da idade e do afeto negativo nas SMC, com adultos mais velhos e sujeitos deprimidos a reportar mais SMC do que adultos mais novos e participantes saudáveis. Sujeitos mais velhos obtiveram resultados objetivos mais baixos numa avaliação da memória objetiva do que os sujeitos mais novos. Os resultados reportam uma relação positiva entre as SMC e o desempenho objetivo nos adultos mais velhos. *Conclusões:* as SMC aparentam ser influenciadas pela idade e pela depressão, mas não predizem, por si só, o desempenho nos testes objetivos.

Palavras-chave: idade; educação; metamemória; QSM; memória objetiva

Abstract

Introduction: Metamemory regards various metacognitive processes that allow us to think about the efficacy and condition of our memory, and to accommodate our performance, which is essential in both learning and recalling information. Subjective Memory Complaints (SMC) constitute a self-appraisal of memory which may or may not be associated with cognitive deficits, confirmed by neuropsychological testing. SMC usually occur in subjects with lower educational attainment, with depressive symptomatology and older subjects. *Aim:* This study intends to investigate whether age, education and negative affect influence metamemory appraisals and the relationship between SMC and objective memory performance. *Results:* Results confirm that age and negative affect do influence SMC reports, with older people and depressed subjects reporting more SMC than younger and healthier participants. Older subjects had lower scores objectively than younger participants. Positive relations were found between SMC and objective performance in older subjects. *Conclusions:* SMC appear to be influenced by both age and depression but do not, by themselves, predict objective memory performance.

Keywords: age; education; metamemory; SMC; objective memory

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Subjective Cognitive Decline	SCD
Subjective Memory Complaints (Scale)	SMC
Mild Cognitive Impairment	MCI
Montreal Cognitive Assessment	MoCA
Geriatric Depression Scale – 15	GDS
Cognitive Functions Dementia	CFD
Auditory Word List Learning Test	AWLT
T1	Trial 1
T2	Trial 2
T3	Trial 3
T4	Trial 4
STR	Short-Term Recall
LTR	Long-Term Recall

Introduction

Memory is the brain's capability to code, store and recall information presented throughout our lives (Kandel, Schwartz, & Jessell, 2001). It is the capacity to encode, accumulate, accommodate and evoke past experiences allowing us to learn and adapt from prior events (Mastin, 2010).

Understanding Memory

According to Kolb and Whishaw, in 2009, memory is divided in two categories: short-term and long-term memories. The short-term memory is responsible for sensory, motor and cognitive memory, that is, working memory. Long-term memory is divided in two categories, as follows:

- Implicit – or non-declarative – memory, which is unconscious and refers to skills we have learned over the course of our lives, habits we have picked up, conditioned responses and reactions and, lastly, priming (technique in which being exposed to a certain stimulus wields an effect on an ensuing stimulus detection or identification without conscious guidance or intention);
- Explicit – or declarative – memory, which is conscious and contains both episodic and semantic memory (Tulving, 1972, as cited in Kandel et al., 2001). The first covers personal and autobiographical memories (e.g. what you did on the 3rd of December 2019), meaning it contains memories that have a place and a time in the individual's life, whilst the latter refers to facts and knowledge (e.g. what is the name of our current President), meaning it contains memories that are not associated to a place or time in the individual's life (Lezak, Howieson, Bigler, & Tranel, 2012).

What Makes Us Remember

Explicit memory depends on Top-Down processing, that is, on conceptually driven processing. The individual reorganizes the data so it can be stored, which will determine the later recall of that information, i.e., because a person plays an active role in processing explicit information, certain internal cues are used when processing information, which can trigger its spontaneous recall later in time (Kolb & Whishaw, 2009).

Declarative memory is found to be integrated in the medial temporal lobe, more specifically in the hippocampal formation. As proposed by Aggleton and Brown, in 1999, the hippocampus,

the fornix, the mammillary bodies and the anterior thalamic nuclei compose what was called an "extended hippocampal system" (Liu, Lee, & Byun, 2007), which is thought to be a key system in memory.

In 1900, Vladimir Bekhterev discovered a correlation between temporal cortex damage and memory impairment; this was confirmed by Wilder Penfield, in 1940, although his findings were not considered relevant as they did not have statistical significance. In 1953, William Scoville originated one of the most studied cases about memory by performing a bilateral medial-temporal-lobe resection on H.M., a severely epileptic patient, in order to control his seizures, leaving him severely amnestic and unable to acquire and retain new memories, adding a new perspective to memory research at the time. Brenda Milner and her colleagues, in the 1950s, also confirmed Bekhterev's findings after examining various patients with this condition and the same type of damage. Furthermore, Milner et al. learned that there were different structures contributing specifically to different types of memory (Kolb & Whishaw, 2009).

Petri and Mishkin, in 1994, proposed a neural basis for explicit memory, showing which anatomical areas they believe were involved in processing declarative memories, after conducting numerous studies with both animals and humans (Figure 1; Kolb & Whishaw, 2009).

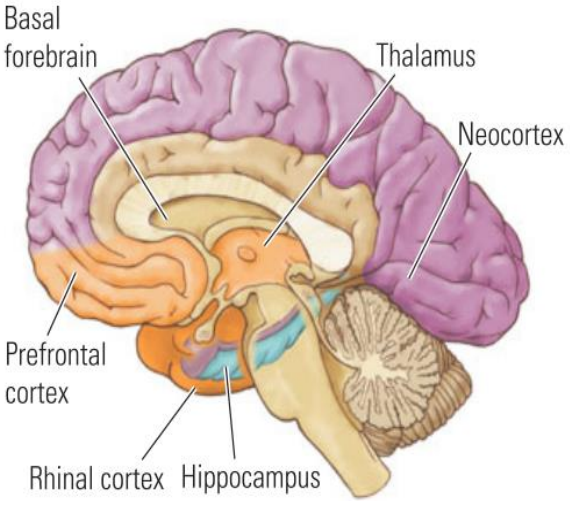


Figure 1. Neural structures involved in Explicit Memory

Episodic memory refers to a series of specific events an individual can recall. According to Kolb and Whishaw (2009), this specific type of memory must be dependent of the medial temporal lobe – as shown by the H.M. case – and, thus, the authors suggest that this structure and the ventral frontal cortex, through the uncinate fasciculus, support episodic memory. This memory is the one impaired when one suffers from amnesia, due to the involvement of the medial temporal lobe and midline diencephalon's structures (Squire, 2004).

Lesions in the left hippocampus are known to lead preferentially to impairments in verbal episodical memory. It has also been discovered that the frontal lobes are responsible for storing, in

the long run, the episodic information, working alongside with other neocortical structures to retrieve it; however, the ability to connect information to the when and where it was acquired is essential to retrieve it accurately (Kandel et al., 2001).

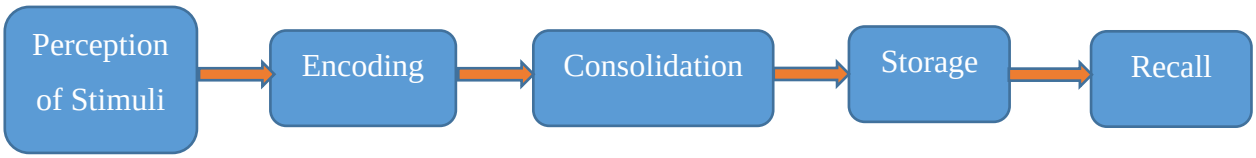
According to Kolb and Whishaw, in 2009, a number of studies were conducted in order to understand the functional impairments caused by the removal or lesion of the temporal lobes, in which it was found that, after left-temporal-lobe lesions, subjects would be impaired when recalling word lists, consonant trigrams and nonspatial associations. It was also found by Milner et al. that lesions on the left temporal lobe resulted in impairments on verbal tests such as the recall of previously presented stories and word pairs, as well as the recognition of numbers and recurring nonsense syllables. Furthermore, it is believed that the hippocampus is responsible for tagging memories according to their context – where and when they happened – which is fundamental for episodic memory (Kolb & Whishaw, 2009).

How We Remember

What we remember begins to form in a very inconspicuous way; it begins with what we perceive with our sensory receptors – either through a visual stimulus or an auditory one – and goes on to a consolidation process until it is stored in long term memory, if ever. In fact, we can understand a bit more about memory if we bear this in mind: we learn so we can remember; it seems very simple and it is so automatic that we fail to pay attention to how we learn.

Due to the explicit long-term memory's intricacy, four different processes are required: encoding, storage, consolidation and recall. Thus, we begin to perceive new information and, according to how great our motivation is and how much knowledge we already have about it, we may encode it in a deeper or shallower manner. After encoding this information, we store it in short-term memory temporarily and, through practice, we consolidate and store it so it can be accessed at any moment later in time. The stored and consolidated information is, eventually, recalled and brought into working memory in order to use it in any given task that requires it (Heßler & Jahn, 2017). Essentially, to remember, we need to learn, and, for that to happen, we need to consider the stimulus to be learnt in order to initiate the entire process. Figure 2, adapted from Mastin (2010), shows the processing involved in memory.

Figure 2. Memory processing



(Sensory channels)

(adapted from Mastin, 2010)

Metamemory

Metamemory is a series of metacognitive processes that allow us to think about the efficacy and condition of our memory, and to accommodate our performance in order to monitor our memories (Siegel & Castel, 2019). Metamemory is influenced by memory, as well as it influences memory itself, by working together with learning and recalling information (Dunlosky & Bjork, 2008).

In 1979, Flavell defined metamemory as a cognitive process of a superior class that regards not only memory function but also beliefs, perspectives, awareness and knowledge about memory function. Nelson, in 1990, stated that this concept can be described by the knowledge and control of our memory, as well as the ability to collect information regarding our current state of memory system (Brandt, Carvalho, Belfort, & Dourado, 2018). In 2009, Dunlosky and Metcalfe described metamemory as the ability to assess and control the individual memory processes (Schmoeger, Deckert, Loos, & Willinger, 2020).

Regulating and adjusting the judgment of our memory capacity is essential in both learning and recalling information (Zhou, Lu, & Dong, 2017). Metamemory can be assessed in terms of different processes, like ease-of-learning judgements, judgments of learning, feeling-of-knowing judgments, source-monitoring judgements and confidence in retrieved answers (Dunlosky, Serra & Baker, 2007, as cited in Dunlosky & Bjork, 2008).

Anosognosia.

This concept is especially important to understand the main point of the present study. It refers to an individual's unawareness of their «neurologic or bodily deficits/conditions. Delusions may be present in order to explain these conditions» (Goodwin, 1989). Thus, it means that a

person's metamemory is altered and, therefore, the individual cannot assess the state of their own memory accurately.

This concept is important so we can understand how, even though the individual might say their memory is unaltered, objective neuropsychological tests show signs of cognitive decline. It is possible that the individual has a poor judgement of its own memory – meaning it is believed as being good when it is not (e.g. saying they started to forget where they put their keys because they have been very stressed and not because of anything wrong in their memory; Dunlosky & Tauber, 2016).

Subjective Memory Complaints (SMC).

According to Yap and colleagues (2019), SMC are self-reported issues regarding memory capacity that may reveal objective cognitive deficits – measured through objective neuropsychological testing. Petersen and colleagues, in 1999 and later in 2001, attributed the increased clinical and research investigation of this concept mainly to the fact that it is a core diagnostic feature of Mild Cognitive Impairment (MCI; Dux et al., 2008), which is defined as cognitive deficits that do not stay within the expected range of normal aging but that are not yet in the range of dementia (Winblad et al., 2004, as cited in Lenehan, Klekociuk, & Summers, 2012). Jungwirth and colleagues, in 2004, in a study with 302 adults aged 75 years old, stand against SMC being a diagnostic criterion for MCI, as most people with memory impairment do not complain about their memory; however, they pose the hypothesis that older people might be able to detect a decline in their memory before objective tests can.

Jones and colleages, in 2019, in a study with 613 adults over 80 years old, found that, although both men and women showed similar objective memory decline rates, women were the only ones to show a decline in subjective memory, indicating a difference between genders in metamemory.

Various studies have been conducted in order to assess the effect of age on metacognitive processes like metamemory but have found inconsistent results (Halamish, McGillivray, & Castel, 2011). Various studies have shown that memory declines related to age are circumscribed to consciously recalling details related to context (Kuhlmann & Undorf, 2018). Cipolli and colleages, in 1990, in a study with 180 adults aged between 50 and 88 years old, found that the older one gets, the worse becomes the objective and subjective memories. Ginó and colleagues, in 2010, found

that older people tend to complain more about their memory than younger people do. However, the authors found that, although SMC can be found in both young adults and older people, it is the type of complaints that change with age. Tandetnik and colleagues, in 2015, conducted a study with 150 participants aged 55 years old or above and found that memory complaints associated with age may bare the highest accuracy when evaluating the possibility of significant memory decline in older people who perform normally on objective testing, as comparing themselves with others of their age group emphasizes the intra-individual nuances in age-related memory decline.

Furthermore, older adults seem more prone to make high-confidence errors, overestimating their performance more frequently than younger adults (Dodson, Bawa, & Krueger, 2007; Irak & Çapan, 2018). Hertzog and colleagues, in 2018, found that individuals with higher educational attainment seem to report changes in their memory capacity more often than those with lower educational attainment, reporting greater changes than those found by objective testing. Wong and colleagues, in 2012, found that the metamemory accuracy tended to decrease with age as recollection quality seems to be impaired by aging.

Hultsch and colleagues, in a study conducted in 1987 which comprised two separate samples of 378 and 447 individuals each, found that, when compared to younger adults, older adults perceive themselves as having suffered a decline in their memory, seeing it as compromised when compared to younger individuals. More recently, in 2018, Irak and Çapan conducted a study with 137 participants ranging from 20 to 60 years old, which found that objective memory performance, as well as accuracy of predictions of said memory performance tend to decrease with age, with younger adults performing better objectively as well as subjectively. Thus, it seems that age constitutes an important role in metamemory and objective memory changes.

Studies have found that educational attainment may have a role in metamemory reports. In a study regarding two experiments with 128 and 96 participants, this seems to be true as younger adults who differ from older adults in this aspect also differ on self-reported memory functioning (Reese & Cherry, 2006). In an attempt to establish a coherent state of the art about cognitive reserve, Stern, in 2002, concluded that individuals with higher education attainment were diagnosed with Alzheimer's disease later on than those with lower education attainment. Thus, one can theorize that the higher the educational attainment, the more resistant one may be to cognitive decline.

Studies have found that symptoms of anxiety, depression and overall negative affect have an impact on the subjective memory complaints incidence (Dux et al., 2008; Song et al., 2020; Steinberg et al., 2013). Nonetheless, according to a review conducted by Reid and MacLullich, in 2006, about SMCs and their role in identifying future cognitive declines, the impact of negative affect, such as depression and anxiety, remains understudied. In 2020, Song and colleagues, found, in a study with 154 individuals above 60 years old diagnosed with MCI, that depressive symptoms are significantly correlated with SMCs, even more so than objective performance, leading the authors to assert that affect can influence subjective memory complaints.

It has been found that SMC can rely on cognitive status; a significant interaction was found between cognitive status and the presence of SMCs in verbal memory (Park et al., 2019). Snitz and colleages, in a study conducted in 2015 with 1980 participants aged above 65 years old, found that the less the participants complained about their memory, the better they performed objectively. However, the authors also found that the poorer objective performances were associated with low SCM, which was associated with poor insight, but also with possible anosognosia. Thus, when considering metamemory and possible cognitive decline, one should bear in mind the possibility of poor insight and anosognosia in subjects who perform poorly in objective testing but do not complain about any subjective memory declines.

In 2019, Park and colleagues, in a study with 219 adults aged 55 years and older, found that subjective memory complaints did not, by themselves, represent a touchstone for cognitive impairment; however, the authors advocate that it can moderate the relationship between both cognitive status and objective performance in memory tasks. Lenehan and colleagues, in 2012, in a study with 75 adults between the ages of 60 and 90 years, found that SMCs were not associated with poorer memory in older adults, meaning that SMCs do not serve as predictors of decrease in cognitive capacity. On the other hand, higher self-reported SMCs have been found to be correlated with poorer memory in healthy subjects (Steinberg et al., 2013; Sundermann et al., 2018); however, the ability to recognize one's own memory state tends to decrease when MCI starts to set in, meaning that underestimating the cognitive deficits is more common as the cognitive decline increases (Almkvist, Bosnes, Bosnes, & Stordal, 2019; Sundermann et al., 2018). In 2019, Park and colleagues suggested that the opposite, i.e. overestimating cognitive deficits, occurs more often in healthy adults, especially in women. One might consider the dismissal of memory problems as

being considered normal for their age instead of something to worry about and, therefore, overestimating their memory capacity as a justification for these results.

In a meta-analysis, performed in 2016, comprising seventeen studies with participants between the ages of 59 and 81 years old, Mendonça and colleagues proposed to review community-based researches on the subjective cognitive complaints as a risk factor for developing neurodegenerative diseases such as Alzheimer's disease. Thus, the authors concluded that the large majority of the studies included in their analysis showed that the presence of subjective cognitive complaints were associated with a 1,5- to 3-fold higher risk of developing MCI or even dementia, showing that subjective complaints could predict the eventual deterioration of one's cognitive functions, specifically memory. Cutler and Grams, in 1988, in a study comprising 14.783 people aged 55 and older, concluded that SMCs are not exclusive to older people and that not all older people seem to complain about their memory. Although these complaints do seem to increase with age, the authors found that less than 30% of the sample reported a decline in their memory in the time span of a year. Mitchell and colleagues, in 2014, performed a meta-analysis comprising 28 studies with a total of 29.723 participants and demonstrated that subjects who report SMC show an increased risk of developing a decline in their cognitive functions in the future.

Subjective Cognitive Decline (SCD).

SCD indicates the individual's experience of their own memory decline, more specifically, experiencing their cognitive function as having decreased without, however, showing any objective signs of such when assessed through neuropsychological testing or daily functioning abilities (Howard, 2020). According to various sources, the elderly that have cognitive tests' results within the normal scope for their age group tend to report perceived decline in their cognitive functioning. In order to assess the individual for the existence of this condition, two major features must be present: the perspective of the individual of a state of cognitive decline and the normal performance in objective neuropsychological tests (Jessen et al., 2020).

Subjective cognitive decline is essential if we want to understand the metamemory state, as it represents the individual's experience of a decrease in the cognitive capacities. According to research, SCD has a special importance in the setting of dementia as it represents an early sign that the individual might develop this condition in the future.

Objectives

Data seems to suggest that age carries a significant effect on SMC, as older people seem to complain more about their memory than younger adults. Additionally, older adults seem to overestimate their memory more often when comparing to younger adults. Furthermore, depressed subjects appear to report SMC more often than those without depressive symptoms. Finally, individuals with higher educational attainment seem to report SMC more often.

Given the lack of a consensus regarding the role of SMC, what influences it and how it can be relevant in neurological aging, further research seems necessary regarding not only age but both depression and education, as well as the relation between SMC and objective memory performance, as the literature fails to reach a consensus about the predictive power of SMC regarding objective results in memory testing.

Thus, in this study, I propose to study (1) whether Age influences one's metamemory and if the latter deteriorates as the individual gets older, (2) whether Education influences one's metamemory and if the latter is inversely proportional to the individual's level of education, (3) whether affect influences one's metamemory and it the latter deteriorates with an increase in negative affect.

Method

Participants

The present study was developed under the norming and validation study of the Cognitive Function Dementia (CFD) battery for the Portuguese population, conducted at the Champalimaud Foundation. It includes participants recruited int the metropolitan areas of Lisbon, Setúbal, Porto, Portalegre and Coimbra.

A total of 290 participants were screened using the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005), according to the Portuguese norms (Freitas, Simões, Alves, & Santana, 2011), in order to exclude cognitive impairment, resulting in 85 participants being excluded from the final sample. Additionally, subjects were screened for Major Depression using the

Geriatric Depression Scale – 15 items (GDS-15; Sheik & Yesavage, 1986) according to Portuguese norms established by Simões and colleagues in 2015, which resulted in 1 exclusion (Figure 3).

All participants were interviewed beforehand and excluded if met any of the following exclusion criteria: diagnosis of any neurological or psychiatric disease (such as stroke, encephalitis and/or head trauma, major depressive disorder, psychosis, etc.); diagnosis of other medical condition that could involve cognition (for example, an oncologic disease that required chemo or brain radiotherapy in the past year) and ongoing medication with possible cognitive impact (such as antidepressants); illiteracy; age < 50 or native language other than Portuguese.

All subjects were submitted to the same experimental research protocol. Informed consent was obtained from all participants and the study was conducted in accordance with the tenets of the Declaration of Helsinki with the approval of the Champalimaud Foundation Local Ethics Committee.

Materials

All subjects were assessed for cognitive impairment and depressive symptoms using the Montreal Cognitive Assessment test and the Geriatric Depression Scale, as aforementioned.

Montreal Cognitive Assessment (MoCA).

The MoCA was initially developed by Nasreddine and colleagues, in 2005, in order to assess cognitive changes and distinguish such alterations between normal aging and pathological deficits. In 2008, Simões and colleagues adapted it to the Portuguese population. It evaluates executive functions, visuospatial capacity, memory, language, and orientation and serves as a screening test for cognitive impairment, with a cutoff at 22 points, meaning that scores below 22 indicate some sort of cognitive impairment (Freitas et al., 2011).

Geriatric Depression Scale – 15 (GDS-15).

The GDS-15, developed in 1986 by Sheik and Yesavage, comprises fifteen questions with Yes/No answers and takes approximately 5 minutes to complete, serving as a shorter version of the GDS-30, created by Yesavage and colleagues in 1983. This self-reported scale assesses the existence of depressive symptoms in older adults, functioning as a screening test. In 2013, Simões and Firmino adapted this test to the Portuguese population (Simões, Santana, & Demência, 2015). The cutoff used in this study was 8 points, the cutoff for minor depression, meaning that all subjects

that scored 9 or above were excluded (Sheikh & Yesavage, 1986; Yesavage et al., 1986; see also Strauss et al., 1991).

Subjective Complaints Scale (SMC).

The SMC was first developed by Schmand and colleagues in 1996, and, in 2008, the Portuguese adaptation was constructed by Ginó and colleagues. This scale was developed in order to understand if the subjects had any complaints about their memory and, if so, to which extent (Schmand et al., 1996).

The SMC is composed by ten questions, answered in a Likert type scale from 0 (nothing) to 3 (a lot). Items 2, 5, 8, 9 and 10 offer a score-range from 0 (nothing) to 2 (a lot) and items 6 and 7 offer a score-range from 0 (nothing) to 1 (a lot), with only items 1, 3 and 4 ranging from 0 (nothing) to 3 (a lot). If subjects score higher than 3 points, it means that there are relevant subjective complaints about their memory and that there might be an actual deficit. Participants can score from 0 to 21 points in total and they are considered to have significant complaints at the cutoff of 3 points, meaning that participants who scored 4 and above presented SMCs (Miyagawa & Iwata, 2016; Schmand, Jonker, Hooijer, & Lindeboom, 1996). Additionally, this scale has proven to have a Cronbach's alpha of .73 (Simões et al., 2015), meaning that it is a reliable scale when it comes to measuring overall memory complaints.

Cognitive Functions Dementia (CFD).

Subjects were assessed using the CFD test-set from the Vienna's Computerized Test System. The CFD test-set was built by T. Jahn and J.B. Heßler, in 2017, in order to better assess mental aptitude of individuals across all age groups and, therefore, better assess demential symptoms and neurocognitive disorders. This test-set evaluates attention – such as alertness, divided attention and processing speed –, verbal long-term memory, executive functions – spatial working memory and cognitive flexibility –, expressive language – verbal fluency and object naming – and perceptual motor functions, such as visuoconstruction (Jahn & Heßler, 2017), lasting, in average, 1 hour.

Auditory Word List Learning Test (AWLT).

The AWLT is a part of the CFD test-set and was built in order to assess verbal learning ability and long-term verbal memory of individuals since how we learn and retain information can be impaired by numerous neurological and psychiatric disorders (e.g. neurodegenerative dementia,

depression). Both the test's reliability (above 0.7) and validity have been proven appropriate (Heßler & Jahn, 2017).

The AWLT consists of a 12-word list presented aurally to the participant during four learning trials and followed by immediate recalls. A short-delayed free recall phase after a 5-minute break, and a long-delayed free recall phase after a 20-minute break, are done. It also includes a recognition task – in which the participant must identify which words were and were not present in the original list. In the free recall phases, the participant is asked to repeat what they remember from the list they heard before without hearing it again (Heßler & Jahn, 2017).

Thus, the AWLT measures the individual's learning ability based on the learning total, the short-term verbal memory, the long-term verbal memory as well as recognition ability, allowing a differential diagnosis based on different aspects of verbal learning and memory skills (Heßler & Jahn, 2017). The more words the subject can learn and remember, the better the results; i.e. higher results in this test mean better learning ability and better memory capacity.

In the current study, we aim to understand if age and education affect one's understanding of their own memory, therefore, we only consider the Auditory Word List Learning Test (AWLT) and the Subjective Memory Complaints Scale (SMC) data in our analysis.

Data Analysis

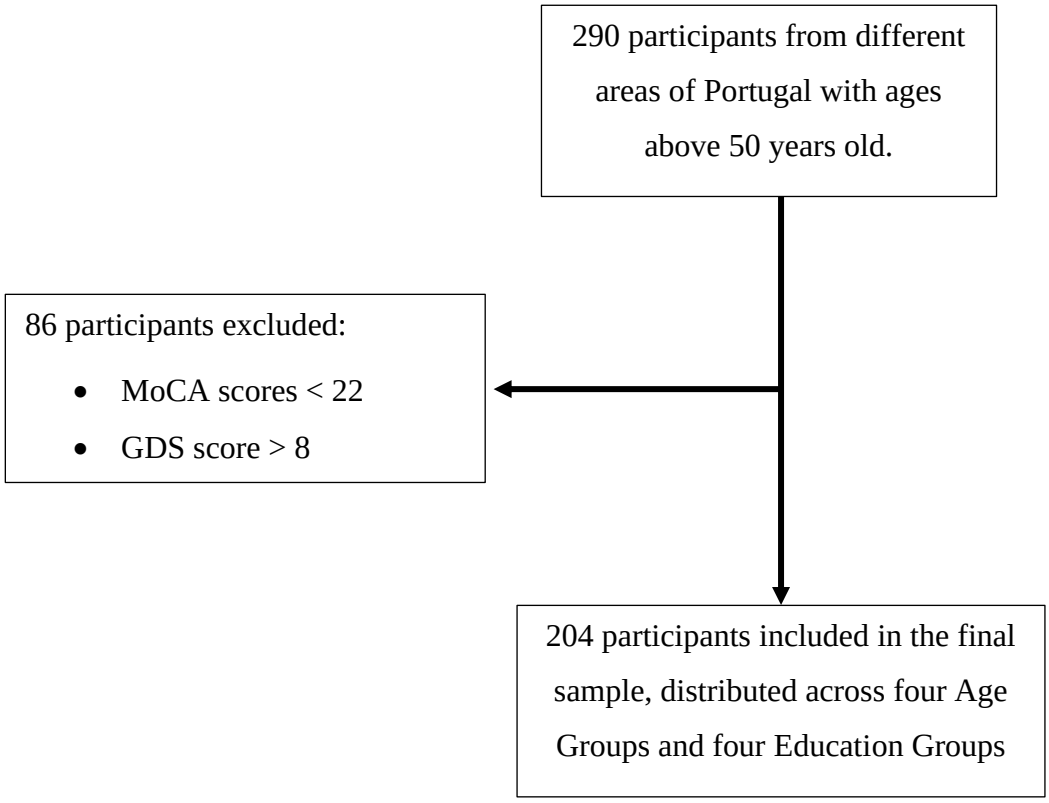
All data analyses were performed using IBM SPSS Statistics Version 25. The Kolmogorov-Smirnov test showed that data did not follow a normal distribution on any variable, although the Levene test showed that the variances were homogeneous. Therefore, we chose to apply non-parametric statistical methods. Descriptive statistics were used for sample's characterization, comparisons between variables were performed with the Kruskal-Wallis one-way ANOVA for k samples with pairwise comparisons, with adjusted *p*-value; the chi-squared test was used for comparisons between categorical variables. Linear regression analysis was performed to examine the significance of age (in years) and GDS scores as influencing factors for the SMC scores. The Spearman's Correlation Coefficient was used between SMC's scores and AWLT performances in order to evaluate whether subjective memory performance was related to objective memory performance.

Results

Sample Characterization

The sample used in this study (Figure 3) initially comprised 290 participants, who were screened for cognitive impairment and depression before being included in the present investigation. 85 participants scored below 22 points in the MoCA and were, therefore, excluded. Additionally, one participant scored above 8 points in the GDS, qualifying for clinically significant depressive symptoms, and was, then, excluded from the study. Thus, the final sample comprised 204 participants, with 55.4% (n = 113) of females.

Figure 3. Flow chart of the study's participants selection process



The participants were distributed according to their age; therefore, four Age Groups created: 1) 50 to 59 years old, 2) 60 to 69 years old, 3) 70 to 79 years old and 4) 80 to 89 years old. Additionally, the 204 participants were also distributed according to their Education level, resulting in

four Education Groups: A) 4 to 6 years of education, B) 7 to 9 years of education, C) 10 to 12 years of education and D) >12 years of education.

Demographic and Clinical Characteristics of the Population

Table 1 shows the demographic characteristics and the neuropsychological performance of the total sample, and of each of the four Age and Education Groups. No significant differences were found on gender distribution across Age and Education Groups (χ^2 (3) = 0.48, p = .92; χ^2 (3) = 4.47, p = .22, respectively).

Table 1.

Sample demographic characteristics and neuropsychological performance

Participants, *N*	204
Gender	
Female, n (%)	113 (55.4%)
Male, n (%)	91 (44.6%)
Age, *years*	
Mean (*SEM*)	64.39 (*9.07*)
Median (*IQR*)	65 (*56 – 71*)
Range	50 – 86
Age Group, *n*	
1) 50-59	71
2) 60-69	67
3) 70-79	56
4) 80-89	10
Education, *years*	
Mean (*SEM)*	11.26 *(4.05)*
Median (*IQR*)	12 (*9 – 15*)
Range	4 – 21
Education Group, *n*	
A) 4-6 years	31
B) 7-9 years	60
C) 10-12 years	31

D) >12 years	82
MoCA	
Mean (SEM)	24.94 (0.15)
Median (IQR)	25 (23 – 27)
GDS	
Mean (SEM)	1.98 (0.14)
Median (IQR)	1 (0 – 3)
SMC	
Mean (SEM)	4.8 (0.21)
Median (IQR)	4.5 (2.25 – 6)
AWLT	
T1	
Mean (SEM)	4.36 (0.1)
Median (IQR)	4 (3 – 5)
T2	
Mean (SEM)	7.27 (0.12)
Median (IQR)	7 (6 – 8)
T3	
Mean (SEM)	8.58 (0.12)
Median (IQR)	9 (7 – 10)
T4	
Mean (SEM)	9.18 (0.12)
Median (IQR)	9 (8 – 10)
STR	
Mean (SEM)	7.86 (0.14)
Median (IQR)	8 (6 – 9)
LTR	
Mean (SEM)	7.61 (0.15)
Median (IQR)	8 (6 – 9)

Note: SMC = Subjective Memory Complains Scale; AWLT = Auditory Word List Learning Test; T1= Trial 1; T2= Trial 2; T3= Trial 3; T4= Trial 4; STR= Short-Term Recall; LTR= Long-Term Recall. SEM = Standard Error of Mean; IQR = Inter-Quartile Range.

The Impact of Sociodemographics

A linear regression analysis, using the enter method, was performed to understand the sociodemographical (age and education) contribution in the SMC scores, resulting in one model (F (2, 201) = 5.1, p = .007; R_a^2 = 0.04), which found that only age was relevant for the SMC scores variance (β = 0.22, t = 3.15, p = .002), explaining 4% of the SMC scores variation. Thus, education has not shown to influence subjective memory complaints was not corroborated.

Analysis according to age.

The performance of each Age group was compared on the SMC and on each trial of the AWLT.

Table 2 shows that SMC scores tend to remain relatively low in all groups, although with tendency to increase with age, showing that older people tend to complain more. As expected, on the AWLT, performances tend to decrease as age increases.

Table 2.

Memory performances according to Age Group

Tests	Group 1		Group 2		Group 3		Group 4		χ^2_{KW}	*p*
	Median (*IQR*)	Mean (*SEM*)	Median (*IQR*)	Mean (*SEM*)	Median (*IQR*)	Mean (*SEM*)	Median (*IQR*)	Mean (*SEM*)		
SMC	4 (1 – 5)	4.03 (0.36)	5 (3 – 7)	5.15 (0.34)	4 (3 – 7)	5.14 (0.44)	5.5 (4 – 7.25)	6 (0.94)	9.34	.025[a]
AWLT										
T1	4 (4 – 6)	4.68 (0.18)	4 (4 – 5)	4.45 (0.16)	4 (3 – 5)	4.05 (0.21)	3 (2 – 4)	3.3 (0.4)	10.61	.014[b]
T2	8 (7 – 9)	7.97 (0.19)	7 (6 – 8)	7.16 (0.2)	7 (6 – 8)	6.64 (0.25)	6.5 (5.75 – 7.5)	6.6 (0.5)	18.17	.000[c]
T3	9 (8 – 11)	9.28 (0.18)	8 (7 – 9)	8.43 (0.18)	8 (7 – 9)	8.05 (0.26)	7.5 (6 – 9)	7.6 (0.52)	19.6	.000[d]
T4	10 (9 – 11)	9.83 (0.2)	9 (8 – 10)	9.04 (0.18)	9 (7.25 – 10)	8.68 (0.26)	8 (6.75 – 10.25)	8.3 (0.65)	17.9	.000[e]
STR	9 (7 – 10)	8.59 (0.23)	8 (6 – 9)	7.79 (0.2)	7 (6 – 9)	7.32 (0.3)	6 (5 – 8.25)	6.1 (0.8)	18.65	.000[f]
LTR	9 (7 – 10)	8.34 (0.25)	8 (6 – 9)	7.63 (0.22)	7 (5 – 9)	6.95 (0.32)	5.5 (4 – 8.25)	6.1 (0.74)	17.57	.001[g]

Note: Group 1 = 50 – 59 years old; Group 2 = 60 – 69 years old; Group 3 = 70 – 79 years old; Group 4 = 80 – 89 years old; SMC = Subjective Memory Complains Scale; AWLT = Auditory Word List Learning Test; T1= Trial 1; T2= Trial 2; T3= Trial 3; T4= Trial 4; STR= Short-Term Recall; LTR= Long-Term Recall. IQR = Inter-Quartile Range; SEM = Standard Error of Mean.

Pairwise Comparisons. with adjusted p-value:

[a] Group 1 *vs* Group 2 = .07; Group 1 *vs* Group 3 = .231; Group 1 *vs* Group 4 = .219

[b] Group 1 *vs* Group 3 = .214; Group 1 *vs* Group 4 = .03*****; Group 2 *vs* Group 4 = .085

[c] Group 1 *vs* Group 2 = .037*****; Group 1 *vs* Group 3 = .001*****; Group 1 *vs* Group 4 = .108

[d] Group 1 *vs* Group 2 = .011*****; Group 1 *vs* Group 3 = .001*****; Group 1 *vs* Group 4 = .032*****

[e] Group 1 *vs* Group 2 = .014*****; Group 1 *vs* Group 3 = .002*****; Group 1 *vs* Group 4 = .049*****

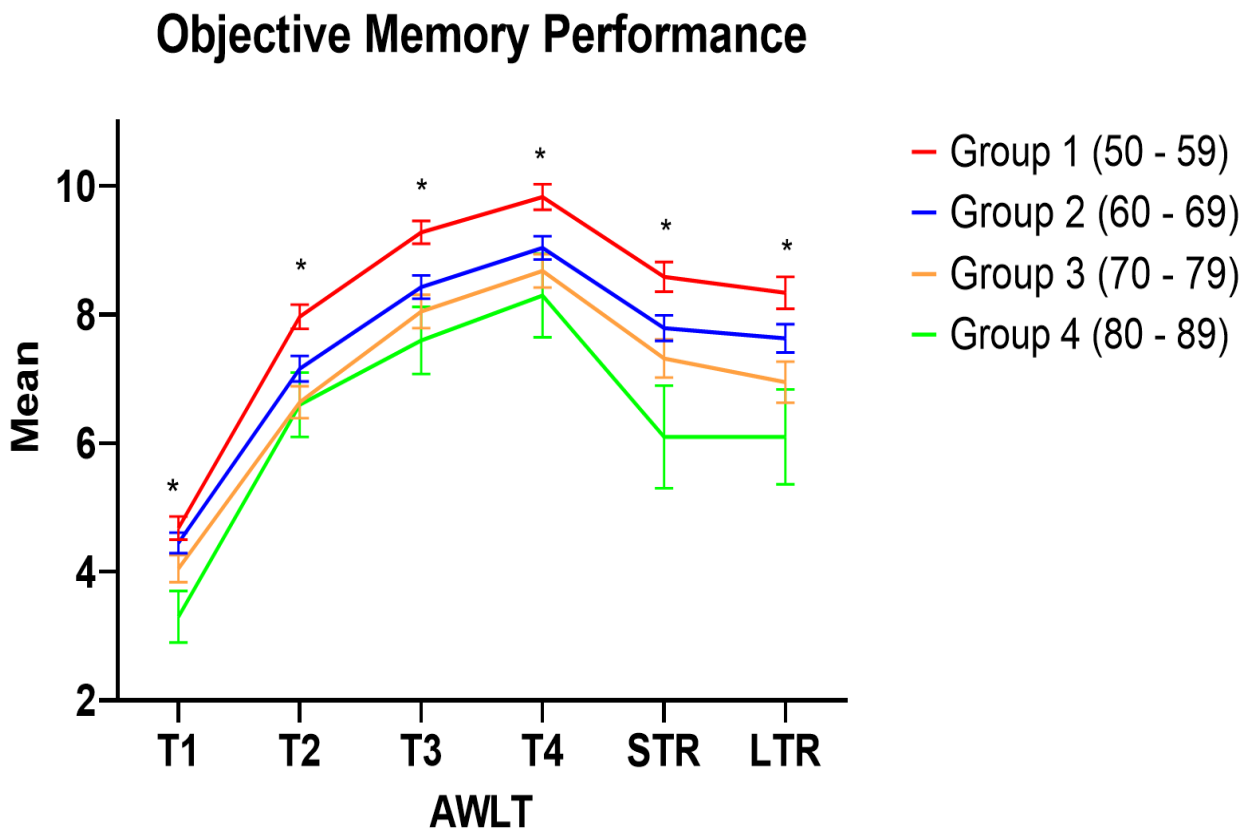
[f] Group 1 *vs* Group 2 = .065; Group 1 *vs* Group 3 = .003*****; Group 1 *vs* Group 4 = .007*****

[g] Group 1 *vs* Group 2 = .157; Group 1 *vs* Group 3 = .002*****; Group 1 *vs* Group 4 = .018*****

* $p < .05$

Data from Table 2, regarding the AWLT performances, was compiled into a graphic in order to make it easier to interpret it visually, as seen on Figure 4.

Figure 4. *Memory performances according to Age Groups*



Note: AWLT = Auditory Word List Learning Test; T1= Trial 1; T2= Trial 2; T3= Trial 3; T4= Trial 4; STR= Short-Term Recall; LTR= Long-Term Recall. Error Bars = ± SEM

Pairwise Comparisons, with adjusted p-value:

T1 Group 1 *vs* Group 3 = .214; Group 1 *vs* Group 4 = .03*; Group 2 *vs* Group 4 = .085

T2 Group 1 *vs* Group 2 = .037*; Group 1 *vs* Group 3 = .001*; Group 1 *vs* Group 4 = 0.108

T3 Group 1 *vs* Group 2 = .011*; Group 1 *vs* Group 3 = .001*; Group 1 *vs* Group 4 = .032*

T4 Group 1 *vs* Group 2 = .014*; Group 1 *vs* Group 3 = .002*; Group 1 *vs* Group 4 = .049*

STR Group 1 *vs* Group 2 = .065; Group 1 *vs* Group 3 = .003*; Group 1 *vs* Group 4 = .007*

LTR Group 1 *vs* Group 2 = .157; Group 1 *vs* Group 3 = .002*; Group 1 *vs* Group 4 = .018*

* $p < .05$

Displayed in the graphic above, groups' learning curve can be observed. Although all groups increase in performances throughout the four learning trials of the AWLT, the younger groups consistently remembered more words than the older ones.

Given the 5-minute and the 20-minute break between the last learning trial and the first recall task (Short-Term Recall) and the last (Long-Term Recall), respectively, it is expectable that subjects forget some of the words from the list. As it can be seen on the graphic, younger participants forgot less than the older ones. The oldest group, however, shows a more accentuated forgetfulness from the last learning trial to the first free recall task.

Subjective and objective memory performance.

We then subdivided the SMC according to the presence and absence of memory complaints, using the defined cut-off of 3, as following: *without complaints* if SMC ≤ 3; and *with complaints* when SMC > 3. As expected, the majority of subjects (75%) scored within the condition "With Complaints". Overall, there were no differences in the SMC scores of the two conditions within the four Age Groups: *Without Complaints* condition: χ^2_{KW} (3) = 5.78, p = .123; *With Complaints* condition: χ^2_{KW} (3) = 1.02, p = .796.

Table 3.

Frequencies of complaints across Age Groups according to the SMC conditions

SMC conditions	Group 1	Group 2	Group 3	Group 4	Total	SMC Scores	
						Median (IQR)	Mean (SEM)
Without Complaints, n (%)	26 (51%)	12 (23.5%)	12 (23.5%)	1 (2%)	51 (25%)	1 (1 – 2)	1.27 (0.1)
With Complaints, n (%)	45 (29.4%)	55 (35.9%)	44 (28.8%)	9 (5.9%)	153 (75%)	5 (4 – 7)	5,97 (0.21)

Note: Group 1 = 50 – 59 years old; Group 2 = 60 – 69 years old; Group 3 = 70 – 79 years old; Group 4 = 80 – 89 years old. Subjective Memory Complaints Scale, using the cutoff point of 3 points. Presence of complaints when SMC score > 3.

AWLT according to the presence and absence of memory complaints.

In Table 4, we compare the AWLT performance according to the defined conditions in the SMC (with or without complaints). As expected, overall, the AWLT scores tended to be lower in the With Complaints condition than in the Without Complaints condition.

The AWLT distributions were assessed across all Age Groups according to their memory complaints conditions (with or without complaints). No differences were found in the participants'

performance through the AWLT in the Without Complaints condition. For the With Complaints condition, however, differences were found between Age Groups in all the AWLT trials.

In Trial 2 (χ^2_{KW} (3) = 16.24, p = .001, n = 153), only groups 1 and 3 were found to have significantly different performances (p = .001). In trial 3 (χ^2_{KW} (3) = 14.25, p = .003, n = 153), group 1 significantly differed from group 2 (p = .048) and from group 3 (p = .004). Performances on trial 4 (χ^2_{KW} (3) = 11.64, p = .009, n = 153) were found to be different only between groups 1 and 3 (p = .015). Regarding the Short-Term Recall phase (χ^2_{KW} (3) = 14.18, p = .003, n = 153), group 1 was found to be significantly different from both group 3 (p = .008) and group 4 (p = .031). Lastly, a similar result was found for the Long-Term Recall phase (χ^2_{KW} (3) = 16.48, p = .001, n =153) where, again, group 1 performances' significantly differed from group 3 (p = .002) and group 4 (p = .037). Although more differences were found through the AWLT trials, they all lost significance after being adjusted for multiple comparisons.

Table 4.

AWLT performance for each Age group across the SMC conditions

AWLT	Without Complaints				With Complaints			
	Median (IQR)	Mean (*SEM*)	χ^2_{KW}	p	Median (IQR)	Mean (*SEM*)	χ^2_{KW}	p
T1	4 (3 – 5)	4.31 (0.22)	2.7	N/S	4 (3 – 5)	4.38 (0.12)	9.93	.019 [a]
T2	7 (6 – 9)	7.49 (0.23)	4.85	N/S	7 (6 – 8)	7.2 (0.15)	16.24	.001 [b]
T3	9 (8 – 10)	9.04 (0.21)	3.74	N/S	8 (7 – 10)	8.43 (0.14)	14.25	.003 [c]
T4	10 (8 – 11)	9.45 (0.25)	5.33	N/S	9 (8 – 10)	9.09 (0.14)	11.64	.009 [d]
STR	9 (7 – 10)	8.33 (0.28)	3.58	N/S	8 (6 – 9)	7.7 (0.17)	14.18	.003 [e]
LTR	9 (6 – 10)	8.12 (0.3)	1.27	N/S	8 (6 – 9)	7.44 (0.18)	16.48	.001 [f]

Note: SMC = Subjective Memory Complains Scale; AWLT = Auditory Word List Learning Test; T1= Trial 1; T2= Trial 2; T3= Trial 3; T4= Trial 4; STR= Short-Term Recall; LTR= Long-Term Recall. IQR = Inter-Quartile Range; SEM = Standard Error of Mean. N/S = Not Significant.
Pairwise Comparisons. with adjusted p-value:
[a] Group 1 *vs* Group 3 $p = .123$; Group 1 *vs* Group 4 $p = .052$; Group 2 *vs* Group 4 $p = .217$.
[b] Group 1 *vs* Group 2 $p = .232$; Group 1 *vs* Group 3 $p = .001$*; Group 1 *vs* Group 4 $p = .132$; Group 2 *vs* Group 3 $p = .3$.
[c] Group 1 *vs* Group 2 $p = .048$*; Group 1 *vs* Group 3 $p = .004$*; Group 1 *vs* Group 4 $p = .132$.
[d] Group 1 *vs* Group 2 $p = .118$; Group 1 *vs* Group 3 $p = .015$*; Group 1 *vs* Group 4 $p = .143$.
[e] Group 1 *vs* Group 3 $p = .008$*; Group 1 *vs* Group 4 $p = .031$*.
[f] Group 1 *vs* Group 2 $p = .221$; Group 1 *vs* Group 3 $p = .002$*; Group 1 *vs* Group 4 $p = .037$*.
* $p < .05$

Correlations between subjective and objective memory performances according to the presence or absence of memory complaints.

Spearman correlations were done in order to understand the relationship between the subjective and the objective performances.

We found that, in the Without Complaints condition, only group 2 had a significant negative correlation between the SMC scores and the AWLT Trial 4 performance (*Rho* = – 0.81, $p = .002$, $n = 12$), meaning that the more the memory complaints, the worse the performance in the last learning trial. Group 4 could not be analyzed as it comprised one single participant (see Table 5).

In the With Complaints condition, it was shown that only group 3 had significant positive correlations between the SMC scores and both the performance in the AWLT Short-Term Recall (*Rho* = 0.31, $p = .04$, $n = 44$), and the AWLT Long-Term Recall (*Rho* = 0.32, $p = .035$, $n = 44$); meaning that the more the participants complained about their memory, the better they performed objectively.

Table 5.

Correlations between the SMC and the AWLT scores across Age Groups in both SMC conditions

AWLT	*Without Complaints*				*With Complaints*			
	Group 1	**Group 2**	**Group 3**	**Group 4**	**Group 1**	**Group 2**	**Group 3**	**Group 4**
T1	0.18 (.373)	-0.05 (.875)	-0.12 (.702)	N/A	0.07 (.642)	-0.07 (.605)	-0.07 (.665)	-0.59 (.096)
T2	0.03 (.886)	-0.35 (.262)	-0.25 (.441)	N/A	0.07 (.643)	0.04 (.78)	-0.19 (.226)	-0.27 (.478)
T3	0.10 (.62)	-0.26 (.409)	-0.23 (.469)	N/A	-0.08 (.594)	0.08 (.572)	-0.21 (.179)	-0.03 (.939)
T4	-0.18 (.372)	-0.81 (.002)*	-0.36 (.246)	N/A	0.13 (.388)	0.18 (.193)	-0.3 (.052)	-0.31 (.414)
STR	-0.08 (.694)	-0.43 (.159)	-0.21 (.516)	N/A	0.05 (.764)	0.03 (.815)	0.31 (.04)*	-0.16 (.69)
LTR	-0.13 (.543)	-0.56 (.058)	-0.03 (.933)	N/A	0.09 (.568)	-0.02 (.892)	0.32 (.035)*	-0.14 (.727)

Note: Group 1 = 50 – 59 years old; Group 2 = 60 – 69 years old; Group 3 = 70 – 79 years old; Group 4 = 80 – 89 years old; SMC = Subjective Memory Complains Scale; AWLT = Auditory Word List Learning Test; T1 = Trial 1; T2 = Trial 2; T3 = Trial 3; T4 = Trial 4; STR = Short-Term Recall; LTR = Long-Term Recall; N/A = Not Available due to n = 1.
Results are shown as Spearman's correlation test (*p*-value).
*$p < .05$.

The Impact of Global Health

A second linear regression analysis, using the enter method, was performed to understand the global health performance (cognitive status – MoCA – and depressive symptoms – GDS) contribution to the SMC scores, as these are variables known to be highly correlated with metamemory (Dux et al., 2008; Park et al., 2019; Song et al., 2020; Steinberg et al., 2013; Sundermann et al., 2018). This analysis resulted in one model (F (2, 201) = 44.81, $p < .001$; R_a^2 = 0.3) isolating GDS as relevant to the SMC scores variation ($\beta = 0.55$, $t = 9.27$, $p < .001$), explaining 30% of the SMC scores variance. Therefore, we tested for the GDS differences between subjects within the same SMC condition. Results showed significant differences between the Without and the With Depressive Symptoms conditions across the two SMC conditions (see Table 6; χ^2 (1) = 5.14, $p = .023$).

Table 6.

Frequencies of depressive symptoms across the SMC conditions

GDS Conditions	SMC Conditions		Total Sample	GDS Scores		SMC Scores	
	Without Complaints	With Complaints		Median (IQR)	Mean (SEM)	Median (IQR)	Mean (SEM)
Without depressive symptoms, n (%)	49 (27.7%)	128 (72.3%)	177 (86.8%)	1 (0 – 2)	1,33 (0.09)	4 (2 – 6)	4,27 (0.2)
With depressive symptoms, n (%)	2 (7.4%)	25 (92.6%)	27 (13.2%)	6 (5 – 7)	6,22 (0.19)	9 (5 – 10)	8,26 (0.66)

Geriatric Depression Scale, using the cutoff point of 4 points. Presence of depressive symptoms when GDS score > 4

As shown by Table 6, participants are unequally distributed within the GDS conditions, with only 27 subjects in the entire sample reporting the presence of depressive symptoms. Nonetheless, participants who did report their existence showed higher scores on the SMC, suggesting that the presence of depressive symptoms may lead to higher reports of memory complaints.

Discussion

The initial aim for this study was to understand the impact of sociodemographic variables – such as education and age – in subjective and objective memory performances.

From the beginning of the study's analyses, it was possible to conclude that education had no role in the reports of SMC. This finding goes against evidence found by Reese and Cherry, in 2006, which stated that younger adults that differed in educational attainment also differed in SMC. Our data also differs from the data reported by Hertzog and colleagues (2018), which found individuals who reported higher educational attainment also reported more SMC. Our results, however, seem to be consistent with the findings of Hertzog and colleagues, in 2019, who found small correlations between education and SMC. This might be due to the participant count difference between education groups, as group A and C were barely above 30 participants and group D was comprised of over 80 participants. This discrepancy in size of group samples might have affected this study's results as it did not allow for fair comparisons between groups, which might account for the lack of influence regarding education on the incidence of SMC. These findings bare relevance for countries with low education level among elders, such as Portugal, as they show SMC to be independent of educational attainment. However, due to the discrepancy in group samples' sizes, it is not advisable to generalize these results and, thus, further research into the matter is needed.

Earlier studies suggest that age has a role in metamemory status, as older adults complain more about their memory (Fastame, 2014; Hertzog, Dixon, & Hultsch, 1990; Hultsch et al., 1987). Our findings suggest that age has a positively significant, yet low, influence on SMC. Although our data shows that older adults do complain more about their memory, this accounts for little variance on the SMC scores, which means that age alone cannot explain SMC. This might be due to the already advanced age of the study's participants, as only people above 50 years old were included, which did not allow for a more extensive analysis on the effect of age on SMC. Earlier studies (Hertzog et al., 1990; Hultsch et al., 1987; Irak & Çapan, 2018; Kuhlmann & Undorf, 2018; Reese & Cherry, 2006; Siegel & Castel, 2019) included participants in their twenties and enrolled in university, allowing for a more thorough analysis on the impact of age on the incidence of SMC, which might explain the age-related differences reported in literature on both subjective and objective memory performance. This is consistent with results reported by Hultsch and colleagues, in

1987, regarding the age-related differences found in their study, as differences appeared to be more evident when comparing younger adults enrolled in university and older community-dwelling adults.

Our results show that older adults tend to perform worse than younger adults objectively, without discriminating between SMC reports. Data also shows that, after a 5-minute break between the last learning trial and the first free recall task of the AWLT, older adults suffer a stronger benign forgetfulness, remembering less words than younger participants. These findings are consistent with the results reported by Siegel and Castel (2019), who found that older adults recalled less words than younger participants. Thus, this not only suggests that age has an impact on objective memory performance but we can also assume that older people, regardless of the presence of SMC, tend to consistently perform worse objectively, both in learning and recall tasks, than younger adults regardless of the presence of self-reported problems concerning memory capacity.

Additionally, our findings regarding objective memory performance in the AWLT trials suggest that, regarding adults who report SMC, younger adults differ from older adults not only in free recall tasks but in learning tasks as well, showing that, in the presence of SMC, older adults tend to perform worse in objective memory tests when compared to younger people. These findings agree with the results reported by Cipolli and colleagues, in 1990, which stated that objective memory performance declined with aging, with older people scoring lower on objective memory measures than younger people. Siegel and Castel, in 2019, reached similar conclusions as their study reported younger adults performing better objectively than older adults. This seems to suggest that objective memory deteriorates with age, which might be due to cognitive developmental changes or to a lack of routine that comes with retirement. The latter might contribute to a decrease in memory capacity as individuals' lives aren't as organized as they used to be, timewise, after retirement.

Thus, older people seem to complain more about their memory than younger adults. However, metamemory processes appear to be adequate when paying attention to objective performances, as older people who reported SMC tended to have lower scores in the AWLT. These findings are consistent with earlier studies such as the ones performed by Fastame, in 2014, and by Hertzog and colleagues, in 2019, which found older adults as the main complainers, and the one performed by Kuhlmann and Undorf, in 2018, which not only found SMC more common in older

people but also showed that such complaints were noticeable in objective memory performance. This might mean older people have found more suitable strategies to measure their memory capacity and compensate possible problems, such as mnemonics. These findings, however, go against those reported by Cipolli and colleagues, in 1990, stating that metamemory also declined with age.

Research on the relationship between subjective and objective memory performance showed that lower SMC were associated with higher scores on objective measures (Snitz et al., 2015). Surprisingly, our findings show a single negative correlation between one of the younger groups and objective performance in the last learning trial of the AWLT in the absence of SMC, meaning that the less this group complained about their memory, the better they performed in the last learning trial, as demonstrated by Steinberg and colleagues (2013), and later by Snitz and colleagues (2015).

Conversely, in the presence of SMC, only one of the older groups showed a significant relationship between subjective and objective performance, specifically in both free recall tasks of the AWLT, however, and contrarily to what was expected, this relationship was found to be positive, meaning that the more this group complained about their memory, the better they performed objectively in the short and long-term recall tasks. Our findings thus suggest that, in the absence of SMC, younger people tend to judge accurately their memory capacity in the last learning trial and that, in the presence of SMC, older people tend to judge their memory capacity incorrectly when it comes to free recall of information.

Our results are consistent with the ones reported by Fastame, in 2014, who also found a positive relationship between SMC and objective performance on free recall tasks. These findings suggest that older people underestimate their memory capacity in free recall tasks. However, it is also important to note that SMC are not sufficient to predict individuals' performances as not only can they be distorted for numerous reasons, such as personality traits, stress and humor (Steinberg et al., 2013) but they might also be influenced by a lack of insight or knowledge about one's own memory. This is consistent with the findings reported by Park and colleagues, in 2019, which stated weak correlations between SMC and objective performance.

Still regarding these findings, it is worth noting that, in the free recall tasks of the AWLT, older adults who reported SMC had lower objective performances the less they complained about their memory, which seems to be in line with the results reported by Snitz and colleagues, in 2015,

as it appears to show an impaired judgement of one's memory capacity, possibly due to a lack of insight, as suggested by the authors, or some other kind of distortion. It is also possible that this failure in measuring their own memory capacity accurately might be due to a short coming in subjective measures, as the SMC does not refer to subjective impairments regarding the recall of lists.

Our data might also go against results reported by Reese and Cherry (2006), regarding the subjects' view on memory problems. The authors argued that younger people took memory problems more seriously than older subjects, which is the opposite of what we observe in our findings, as older people report more SMC and, although they seem to be accurate in their self-assessment, they seem to underestimate their memory capacity, meaning they take their memory problems more seriously. This also goes against findings reported by Irak and Çapan (2018), showing older people as more prone to overestimate memory ability. This might be explained by what has been discussed before, meaning older people might worry more about memory changes instead of discarding them as normal for their age and, therefore, underestimate their objective memory capacity instead of overestimating it.

The absence of any significant relationship between subjective and objective memory performance in the condition Without Complaints seems to go against what has been reported in literature regarding higher objective scores when scoring lower on subjective measures. This adds to the body of research stating that SMC alone cannot predict objective memory performance (Hertzog et al., 1990; Park et al., 2019; Reid & MacLullich, 2006; Roberts, Clare, & Woods, 2009; Schmand et al., 1996).

One limitation, found in the literature, worth mentioning was the lack of consensus on the measures used to evaluate SMC in earlier studies, as many of them used one single question (e.g. "do you have complaints about your memory?"), often unvalidated, to measure such a complex concept. Some studies use different scales to measure SMC and others operate with subscales from several questionnaires to evaluate the presence or absence of SMC. This lack of consensus in literature on how to measure this concept affects comparisons between studies as data seems to differ significantly. Consequently, this impairs the ability to compare different studies to the results found in this work.

Depression has been shown to influence SMC incidence (Park et al., 2019; Song et al., 2020; Steinberg et al., 2013) as depressed subjects tend to report more SMC (Lenehan et al., 2012).

This is argued by Roberts and colleagues, in a 2009 review, as an effect of depression on how individuals perceive their memory problems, enhancing them due to a more negative perspective. This suggests that people with depressive symptoms might see their memory problems as more serious than they are. Steinberg and colleagues, in 2013, found that SMC were more common in subjects with depressive symptoms and that SMC, in turn, were associated with episodic memory.

Data from this study seems to suggest that depression does influence SMC. Our results go accordingly with the ones found by Song and colleagues, in 2020, which state that SMC might be caused by the presence of depressive symptoms instead of objective memory problems. In a review published in 2006, Reid and MacLullich found that depression might work as a mediator between SMC and objective performance. Our findings seem to support this idea, as SMC seem to be explained by the presence of depressive symptoms, which could be interpreted as a more negative view of memory problems and, therefore, a distorted appraisal of one's memory ability (Dux et al., 2008).

Thus, regarding our results, it has been shown that depressed subjects scored higher on the SMC. However, the number of participants who did not report depressive symptomatology is noticeably higher, and, therefore, the results cannot be generalized as there is not enough representation for the presence of depressive symptoms and its role on the report of SMC.

Limitations

This study carries some limitations that warrant mentioning. Our findings might have been affected by a lower participant count in group 4 (80 to 89 years old), as it was comprised by only 10 participants whilst the remaining groups were composed by over 55 participants. A higher group sample would have permitted better comparisons and, therefore, stronger conclusions.

Regarding the group 4 composition still, when subdividing participants into SMC conditions, this group's data could not be compared with the remaining groups on the absence of SMC as it was comprised by only one participant, preventing any possible comparison from being performed, and consequently, any possible conclusion regarding age differences between the remaining three groups and group 4's performances from being drawn.

Regarding the education hypothesis set in the beginning of this study, group samples also stood as a limitation for this investigation as participants were not equally distributed across all

education groups, which could have impaired our analyses regarding the impact of the educational attainment on SMC.

The lack of a generic definition of SMC and consequential existence of different terms to refer to it, such as subjective cognitive impairment, SMC, subjective cognitive complaints (SCC), and subjective memory impairment (SMI), as mentioned by Mendonça and colleagues, in 2016, created a genuine handicap when it came to comparing our findings with the ones reported across distinct studies.

Regarding the analysis of the impact of global health on SMC, specifically the impact of GDS, it must be noted that participants were unequally distributed between the GDS conditions, which impairs the generalization of the reported data.

Conclusions

In sum, age and depression play an important role in the incidence of SMC. However, subjective memory performance does not, by itself, predict objective memory performance, as the moderate correlations found in the present study between the two types of performance are marginally significant when SMC are present. Additionally, depressive symptoms appear to influence SMC, as depressed subjects scored higher on the SMC.

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