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Cognitive plasticity, cognitive functioning and quality of life (QoL) in a sample of young-old and old-old adults in southern Spain

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Abstract
Background and aims The present study was designed to assess the differences in cognitive plasticity, cognitive functioning and quality of life (QoL) in young-old and oldold adults, and to determine whether variables related to QoL can predict cognitive plasticity in old age. Methods The study population consisted of 215 people living in sheltered accommodation for elderly people in southern Spain. Participants were divided into two groups according to age: young-old aged (between 65 and 80 years) and old-old (81 and above). Participants were assessed by means of cognitive performance tests, a QoL questionnaire, and the auditory verbal learning test-learning potential (AVLT-LP) as a measure of cognitive plasticity.
Results No significant differences were found in cognitive plasticity between the young-old and old-old adults, although the former performed better on immediate and sustained verbal recall. Likewise, no significant inter-group differences arose in most of the QoL variables. However, differences in cognitive plasticity did appear as a function of the level of cognitive functioning of the old adults, and cognitive functioning has been shown to be the best predictor of cognitive plasticity in old age.
Conclusions Differences in cognitive plasticity between young-old and old-old adults only appear when the cognitive functioning of individuals is taken into account, rather than their age group. The variables cognitive functioning, social integration and education level appear to be the best predictors of cognitive plasticity in old age.

Keywords Cognitive functioning Cognitive plasticity Old-old adults Quality of life Young-old adults

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Introduction

In the field of gerontology, old age has traditionally been regarded as a general process of decline. However, thanks to studies carried out by Baltes et al. [1] in the 1980s, aging has more recently come to be viewed as a phase of life in which cognitive functioning presents a combination of gains and losses, and in which major inter and intra-individual differences are found. Nevertheless, as age progresses, the balance tends to become less positive and decline appears to be more generalized [1, 2].

In this area of study, several lines of research have been proposed, including the concept of cognitive plasticity enduring throughout the life-cycle [1]. Cognitive plasticity (also known as cognitive reserve, or learning potential) is a behavioral construct supported by experimental methodology (pretest/training/post-test designs) and measured by both behavioral changes in performance and changes in functional brain activity after cognitive training [3]. It is also related to motivation and varying individual circumstances [4]. Cognitive plasticity, thus, denotes the capacity for change in the possible range of cognitive performance in conditions of optimal performance, which

may range from the simple retest to extended periods of cognitive training [5].

As part of the research into this construct, various studies have established the occurrence of plasticity in healthy old people [4, 7], together with a marked diminishment of plasticity in old people with cognitive decline, and have noted the implications of this phenomenon for early diagnosis of dementia [7–9]. Other related areas have been analysed, such as the possibility of predicting cognitive evolution in old people by means of cognitive plasticity [9–11], the implications of plasticity in cognitive training for old people [11], the influence of specific variables such as education, physical exercise and diet on cognitive plasticity [4], and age-related differences in plasticity [12–14].

This last line of research is of particular interest, bearing in mind the distinction increasingly made in the literature between so-called young-old adults and old-old adults. According to Baltes and Smith [15], the boundary between the two is situated between 80 and 85 years old, since this is the age at which 50 % of people in each generational cohort have died. This division would seem to be justified by the important differences which have been found between the two populations: basically, while research data allow us to be optimistic regarding the possibility of maintaining a satisfactory level of physical and cognitive functioning in young-old adults [16], studies of old-old adults suggest that the decline is more generalized and losses appear to be greater than the gains [15].

In relation to the question of whether the two populations present differences in cognitive plasticity, Yang et al. [13] examined whether the plasticity demonstrated in a group of young-old adults could be extended to the old-old adults, and whether plasticity and its age-related changes are modulated by the level of cognitive functioning. The authors found an improvement in cognitive performance in both groups independently of their level of cognitive functioning, in all the trained tasks, although the improvement shown by the group of old-old adults was less marked.

A follow-up of the sample was undertaken in a later study [14]. Results showed that the effects of training were maintained in both groups for a period of 8 months after the initial assessment, although the benefits and overall level of performance in the younger group were greater. According to these data, the authors suggested that plasticity is an enduring phenomenon and may be preserved even in people over 80 [14].

Cognitive plasticity has also been studied in memory tasks, in which an age-related deterioration has been noted [17, 18]. For instance, Shu-Chen Li et al. [19] carried out training in a working memory task in a group of adults aged from 20 to 30 years and another group of old adults aged 70–80 years. They found substantial performance gains on the practice task in both groups, with no intergroup differences in the maintenance of practice gains and near-transfer effects after 3 months. However, decrements did appear in post-practice performance among the older adults, but not the younger ones.

In this context, cognitive plasticity may be seen as a variable of particular interest, since it allows us to estimate learning capacity and to relate it to other factors, whether biological and neurological [4, 6, 12] or psychological and cognitive [8, 15].

The review of Greenwood and Parasuraman [4] suggests that variables related to exposure to new experiences and lifestyle stimulates and maintains cognitive plasticity in advanced age. Accordingly, it seems reasonable to assume that cognitive plasticity is associated with QoL, defined as ‘‘an individual’s perceptions of their position in life in the context of the culture and value system where they live, and in relation to their goals, expectations, standards and concerns’’ [20]. Previous studies such as that by Fernández-Ballesteros and Zamarrón [21] have shown significant differences in QoL related to the old person’s age group, with more favorable results for the young-old adult group in variables such as education level, income level, social integration, and level of activity and leisure [21]. Similarly, several studies have related QoL with cognitive functioning, so that QoL appears to be one of the variables associated with the inter-individual differences in cognitive functioning found in old age [22, 23]. With these considerations in mind, the aim of the present study was to analyse the construct of QoL in relation to the old people’s age group and to determine its association with cognitive plasticity.

Specific study objectives were:

1. To establish differences in cognitive plasticity and QoL variables between young-old and old-old adults.
2. To relate cognitive status (high and low levels of cognitive functioning) with cognitive plasticity in the two age groups.
3. To determine which QoL and cognitive variables are capable of predicting cognitive plasticity in old people.

Methods

Study population

The study was conducted with 215 participants, of whom 89 (40 %) were men and 136 (60 %) were women. Average age was 80.80 ± 7.17 years (± S.D.), age range 65–96 years. Participants were selected from sheltered accommodation for elderly people in southern Spain. The subjects were divided into groups according to age range, cognitive plasticity and level of cognitive functioning, as described in the 'Study design' section.

Measures

Mini-mental-state examination (MMSE) [24]

This is a screening instrument used in the detection of cognitive decline and can rapidly and systematically assess a set of cognitive functions which are likely to be affected in old people (temporal–spatial orientation, registration, attention and calculation, recall, language, repetition and complex commands). The final score is frequently used as a global index and as a method for following the evolution of cognitive functioning in processes such as cognitive decline and dementia. The test has been shown to be effective in the diagnosis of mild cognitive impairment [25, 26]. The concurrent validity of the MMSE with a wide neuropsychological battery has been shown in a previous investigation [27].

Auditory verbal learning test-learning potential (AVLT-LP) [28]

Deriving from the classic verbal memory test by Rey (1964), this learning potential test consists of the presentation of 15 common words, which participants are required to repeat immediately after hearing them. Following the method of pretest/training/post-test designs used to assess cognitive plasticity or learning potential, the list of words is presented seven times in a single session. The first two presentations (pre-test) follow standard procedure, and the next two constitute the training phase (training) and include feedback on performance, consolidation and motivation to improve performance, support, and repetition of both forgotten and remembered words. The fifth and sixth presentations (post-test) represent the post-test and again follow standard procedure. A seventh presentation is carried out after an interference task (in this case, the MMSE test). The scores used in the present study were as follows: (1) each of the six assays in the AVLT-LP; (2) AVLT-LP pre: the score obtained from the average number of correct recalls in the first two presentations; (3) AVLTLP gain score: the difference between AVLT-LP pre and AVLT-LP post (average number of words correctly recalled in the last two presentations); (4) AVLT-LP sustained recall: the number of words recalled by the subject in the seventh presentation. Previous studies show that the training given in the intermediate presentations significantly improves subjects' performance, to the extent that AVLTLP gain scores have become established as a measure of cognitive plasticity in various populations such as those with schizophrenia and dementia [29] and has been validated in Spanish populations in both healthy subjects and those with cognitive impairment [10, 30, 31].

Cuestionario breve de calidad de vida/Short QoL questionnaire [21] (CUBRECAVI)

The CUBRECAVI provides a multi-dimensional evaluation of the QoL in old adults. The questionnaire consists of 21 sub-scales grouped in the following dimensions: (a) health (subjective, objective, psychic); (b) social integration; (c) functional abilities; (d) activity and leisure time; (e) quality of environment; (f) satisfaction with life; (g) education; (h) income; (i) health and social services. It has been shown to be reliable, with moderate indices of internal consistency (0.70–0.92) and has been validated and assessed for the Spanish population and various South American countries [21].

Study design

The research plan was first presented to the University of Granada's Ethical Committee for Health Sciences. On obtaining approval, the research was presented in 2010 to eight nursing homes for elderly people (4 public, 4 private), with a view to seeking their participation. The personnel were asked to make a pre-selection of participants with the following characteristics: age 65 years or over; absence of serious illness or dementia; absence of motor and or/sensorial deficits. Once selected, participants were informed individually of the objectives of the study and of the assessment to be carried out, so that they could give their informed consent. Only a small number of selected participants declined to give their consent and to participate in the experiment. The characteristics of these subjects with respect to the variables of age, education level and gender were similar to those who did take part. Assessment was conducted by experienced psychologists in two sessions with a maximum duration of 1 h each. In the first session, sociodemographic data were collected by means of a semistructured interview and the CUBRECAVI questionnaire was given. The second session was devoted to the AVLTLP task and the MMSE.

A quasi-experimental ex-post facto design was adopted for the research. Bearing in mind the study objectives, the sample was classified according to three factors: age range, level of cognitive functioning, and presence or absence of cognitive plasticity determined by means of the AVLT-LP gain score. Two age groups were established, the first consisting of subjects aged 80 years or under (young-old group) (n = 95, age range = 65–80, average age = 76.50 ± 2.12), and the second of subjects aged 81 and over (old-old group) (n = 120, age range = 81–96, average age = 87 ± 5.29) (no significant differences between groups were found in years of education). For classification based on cognitive function, MMSE scores and other measures were taken as references, in line with previous researches [26, 29], and three groups were established: (1) cognitive decline group (n = 69): MMSE score 20 points or below, range 10-20 (MMSE average score = 16.17; SD = 2.73), memory complaints, and low level of functional abilities; (2) normal aging group (n = 119): MMSE score 20–26 points (MMSE average score = 23.70; SD = 1.93), and moderate scores in functional abilities, health and satisfaction with life; and (3) successful aging group (n = 27): MMSE score 27 points or higher (MMSE average score = 28.28; SD = 0.92), high cognitive functioning, and high scores in functional abilities, satisfaction with life, and objective and subjective health [32].

For classification of subjects in terms of cognitive plasticity, the AVLT-LP gain score was taken into account. This was calculated from the difference in pretest post-test scores, on the basis of which participants were divided into two groups: people with cognitive plasticity (n = 116, average gain score = 5.15; SD = 1.49, range = 3.5–11), who achieve a pretest post-test improvement of at least 1.5 standard deviation from the pretest score, and people without cognitive plasticity (n = 109 average gain score = 1.63; SD = 1.01, range = 0–3), who present improvements of less than 1.5 standard deviation from the pretest score. Boundaries were established with a significance criterion based on the standard for clinical significance of treatment effects [33]. The sensitivity of gain score criteria for classifying the old population in terms of people with or without cognitive plasticity has also been demonstrated [10].

Statistical analyses

For analysis of the first study aim, an inter-group ANOVA was carried out with age group as independent variable and the following results as dependent variables: performance in all AVLT-LP assays, AVLT-LP pre, AVLT-LP post, AVLT-LP sustained recall score, AVLT-LP gain score, MMSE score and scores for various sub-scales of the CUBRECAVI questionnaire. For variables for which the results did not seem to have sufficient statistical power, a linear model was carried out comparing the age range and taking the MMSE scores as a co-variable.

As stated above, the second study's aim was to examine the association between cognitive plasticity and participant's age in relation to the level of cognitive functioning. For this, a general linear model with repeated measures was conducted, in which application of the various AVLT-LP assays was taken as the intra-subject factor. This was compared with two inter-subject effects, the old person's age group and level of cognitive functioning.

A stepwise linear regression model was performed to analyse possible predictor variables for cognitive plasticity in old age (assessed according to the AVLT-LP task in old age, with cognitive plasticity as dependent variable and the other variables measured in the study as independent or predictor variables).

Statistical analysis of data was carried out with the statistics program SPSS 15.0 for Windows. Only p values B0.05 were considered statistically significant.

Results

Our first aim was to determine whether there were differences in cognitive plasticity and QoL variables between young-old and old-old adults. In the ANOVA analysis conducted on cognitive plasticity, immediate and sustained recall of words and general cognitive functioning of the two age groups, statistically significant differences between the two groups were revealed in the MMSE (F(1.214) = 7.955, p\0.005), all the AVLT-LP assays (see Fig. 1), AVLT-LP sustained recall (F(1.214) = 13.569, p\0.001), AVLT-LP pre (F(1.214) = 15.647, p\0.001) and AVLT-LP post (F(1.2214) = 10.593, p\ 0.001) (see Table 1).

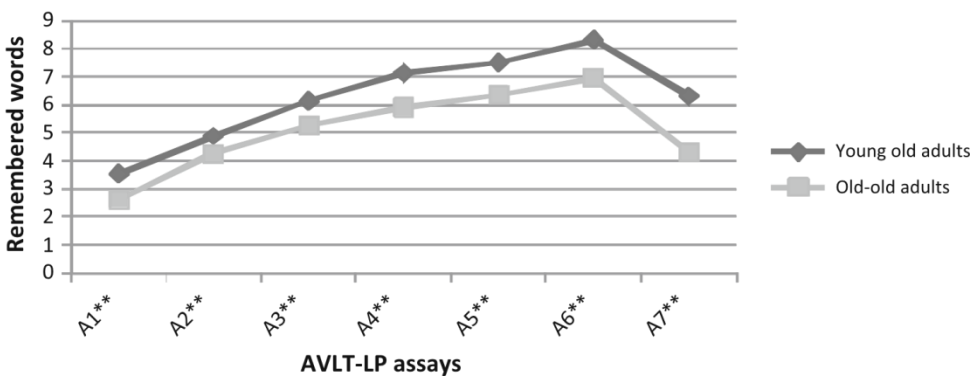

Fig. 1 Number of words from the AVLT-LP recalled by the two groups of old adults in the various task assays. *A1–A6* assay, *A7* sustained recall, ** $p \leq 0.01$

Cognitive variables and QoL	Young-old adults	Old-old adults	F	Sig.	Cohen's d	Statistical power
MMSE	22.653 (4.343)	20.780 (5.351)	7.955	0.005	0.383	0.835
AVLT-LP pre	5.984 (2.499)	4.754 (2.072)	15.647	0.001	0.536	0.947
AVLT-LP post	11.693 (4.238)	9.843 (4.094)	10.593	0.001	0.444	0.902
AVLT-LP gain score	5.709 (3.345)	5.089 (3.328)	1.854	0.175	0.186	0.366
AVLT-LP sustained recall	6.469 (0.400)	4.338 (0.418)	13.569	0.0001	0.082	0.955
General health	2.965 (0.562)	2.977 (0.526)	0.027	0.870	0.022	0.947
Subjective health	2.587 (0.943)	2.822 (0.902)	3.447	0.065	0.255	0.511
Objective health	3.303 (0.427)	3.204 (0.435)	2.794	0.096	0.23	0.401
Mental health	3.007 (0.687)	2.922 (0.659)	0.869	0.352	0.126	0.226
Social integration	2.077 (0.539)	2.123 (0.522)	0.414	0.520	0.087	0.103
Functional abilities	3.034 (0.893)	2.706 (0.945)	6.762	0.010	0.357	0.708
Activity and leisure time	2.097 (0.545)	1.996 (0.477)	2.097	0.149	0.197	0.267
Environmental conditioning	3.010 (0.395)	2.970 (0.403)	0.513	0.474	0.100	0.078
Satisfaction with life	2.573 (0.926)	2.812 (0.918)	3.545	0.061	0.259	0.496
Education	1.052 (1.112)	0.919 (0.805)	1.024	0.313	0.137	0.110
Social services and health care	2.899 (0.649)	3.043 (0.547)	3.091	0.080	0.240	0.362

Statistical power calculated with a= 0.05

However, as shown in Table 1, there were no significant differences between the two groups in cognitive plasticity as measured by the AVLT-LP gain score, although the gain was slightly lower for the old-old group.

As the low statistical power of this result may indicate a type-II error, an ANOVA was carried out, controlling the effect of the MMSE as covariable (see Table 2). Again, no conclusive results were obtained with respect to the ALVT-LP gain score. However, when the differences in that variable were analysed in relation to cognitive status as assessed by the MMSE, there were clear differences between groups (F(1.214) = 7.552; p\0.0001; g= 0.114, statistical power = 0.999). In contrast, analysis of the distribution of participants in terms of presence/absence of plasticity and age group (young-old/old-old) revealed homogeneous sample distribution (Chi square (1) = 0.598; p[0.05).

With regard to the QoL variables, the only significant inter-group differences revealed by the ANOVA related to functional abilities, in favor of young-old adults (F(1.224) = 6.762, p\0.01). No differences between the two age groups were shown in the remaining QoL dimensions, as measured by the CUBRECAVI questionnaire (see Table 1). Again, in view of the low statistical power of some of these variables,

Table 2 General linear model between young-old adults and old-old ng the MMSE[a] score as co-variable

Cognitive variables and QoL	Type III sums of squares	F	Sig.	g_2 partial	Statistical power
AVLT-LP gain score	0.382	0.093	0.761	0.186	0.061
Subjective health	32.925	38.366	0.0001	0.202	1.000
Objective health	68.284	323.372	0.0001	0.680	1.000
Mental health	35.251	88.807	0.0001	0.369	1.000
Social integration	18.479	68.975	0.0001	0.312	1.000
Functional abilities	18.729	25.488	0.001	0.144	0.999
Activity and leisure time	14.680	57.220	0.001	0.273	1.000
Quality of environment	50.309	388.629	0.0001	0.719	1.000
Satisfaction with life	27.440	32.853	0.001	0.178	1.000
Education	0.376	0.575	0.449	0.004	0.117
Social services and health care	28.572	83.341	0.0001	0.354	1.000

Table 1 Means and standard deviations (between brackets) of cognitive functioning, cognitive plasticity and QoL in the two age groups and

inter-group ANOVA (young-old and old-old adults) a general linear model analysis was carried out, with the

[a] The co-variables were analyzed with MMSE values = 22.125

MMSE score as co-variable (Table 2). It revealed significant differences in all the assessed variables except the CUBRECAVI sub-scale ‘‘education’’ (see Table 2). cognitive functioning of participants. In this regard, the

The second study aim was to establish differences in general linear model with repeated measures and two factors cognitive plasticity as a function of the age and level of (age group and level of cognitive functioning) (see Table 3)

Table 3 Repeated measures general linear model for the factor of AVLT-LP applications, including the factors of 'age group' and 'cognitive functioning' of the old adults

Effect		Value	F	p	g^2 partial	Statistical power
AVLT-LP assays	Trace of Pillai	0.716	103.785	0.001	0.716	1
AVLT-LP assays 9 age group	Trace of Pillai	0.027	1.165	0.328	0.027	0.477
AVLT-LP assays 9 cognitive functioning	Trace of Pillai	0.116	2.549	0.005	0.058	0.916
AVLT-LP assays 9 age group 9 cognitive functioning	Trace of Pillai	0.020	0.426	0.934	0.010	0.233

Table 4 Contingency table for the two groups according to cognitive functioning and cognitive plasticity of the old adults

AVLT-LP with plasticity/without plasticity		Cognitive functioning			Total
		Successful aging group	Normal aging group	Cognitive decline group	
Plasticity	Young-old	8	35	12	55
	Old-old	15	32	13	60
	(v^2_2 = 2.091, p = 0.351)				
No plasticity	Young-old	3	28	12	43
	Old-old	2	24	32	58
	(v^2_2 = 7.357, p = 0.023)				

revealed statistically significant differences between the two groups in the AVLT-LP assays with respect to cognitive functioning. In contrast, performance on the AVLT-LP assays did not vary significantly as a function of participants' age (see Table 3), although, again in this case, the statistical power was not sufficiently conclusive to reject the hypothesis. A further analysis related to the distribution of old-old adults in terms of presence or absence of plasticity, taking into account the variables of age and cognitive status for each group (Table 4). In this respect, distribution of the group of subjects with cognitive plasticity was shown to be homogeneous (v^2_2 = 2.091, p[0.05); however, significant differences in distribution were revealed for the group of subjects without plasticity (v^2_2 = 7.357, p\0.05) (see Table 4).

Lastly, our third aim was to analyse QoL and cognitive variables for predictability with respect to old adults' cognitive plasticity. For this, a step-by-step linear regression model was carried out, taking cognitive plasticity as measured by the AVLT-LP task gain score as dependent variable, and age, MMSE score and all the CUBRECAVI sub-scales as predictor variables. Results show that the variables which best predict plasticity are, in order, cognitive status, social integration, and education level (Table 5). These variables were shown to explain 21.5 % of the variance in plasticity as measured by the AVLT-LP gain score.

Discussion

The first aim of this study was to ascertain any differences in cognitive plasticity and QoL in young-old adults (65–80 years) and old-old adults (81 years and above). In line with previous research [18, 19] our results demonstrate differences between the two age groups in initial scores in the AVLT-LP, which are maintained in all assays, including sustained recall. Nevertheless, no significant differences were found between the two age groups with respect to cognitive plasticity, according to the AVLT-LP gain score. However, it should be noted that the analyses do not have sufficient statistical power with respect to the AVLT gain score differences to enable us to accept either the null hypothesis or the alternative hypothesis, probably due to the variability of scores obtained with this variable by the subjects in each age group. By contrast, the various analyses carried out do clearly show that the AVLT-LP task gain score is related to cognitive status, as assessed by

Table 5 Linear regression analysis of the 'cognitive plasticity' variable (AVLT-LP gain score) with the predictor variables of age, general cognitive functioning and QoL of the old adults

Outcome variable	Predictors	R_2	Error	b	t	g/l	p
AVLT-LP gain score	MMSE	0.133	2.01250	0.364	5.571	1/220	0.0001
	MMSE ? social integration (SI)	0.183	1.95808	-0.226	-3.527	2/220	0.001
	MMSE ? SI ? education	0.215	1.92400	-0.189	-2.867	3/220	0.005

the MMSE task. Analysis of the distribution of participants with and without plasticity in the two age groups did reveal homogeneous sample distribution, when participants' cognitive status was not taken into account. These results show that, in the study sample, the presence of participants with cognitive plasticity, who are capable of benefiting from the task training phase, occurs independently of the age group to which they belong (young-old/old-old adults). This coincides with findings by other researchers [1, 3, 4, 13, 14] and offer further evidence in support of the claim that the capacity to learn is maintained into advanced old age. This in turn may justify the effectiveness of cognitive training programs for the prevention of cognitive decline in old age [11].

A further finding with regard to our first aim relates to the absence of statistically significant differences in QoL between the two age groups, when this variable is analysed without taking cognitive status into account, except in the case of functional abilities, in which young-old adults show clear superiority in their level of independent and autonomous functioning. These results seem to support previous studies—whether transverse [35] or longitudinal [36]— which do not establish differences in QoL between youngold and old-old adults. However, differences in favor of young-old adults do appear in all the subscales (except ''education'') of the QoL measure, when account is taken of participants' cognitive status as measured by their scores on the MMSE. This result is in line with previous research such as that by Townsend [34] and indicates that the passing of the years is one of the factors most closely associated with the need for care and support, the group of old-old adults presenting a higher degree of incapacity and/or dependence and a larger number of physical deficiencies [35]. In contrast, our results contradict the studies cited by Ferna´ndez-Ballesteros and Zamarro´n [21], which indicate differences in Spanish populations in favor of young-old adults with regard to variables such as education level, social integration and level of activity and leisure, independently of the cognitive status of the old adults. In the present study, no significant age-related differences were found in these variables except when participants' cognitive status was controlled.

Our second aim was to analyse the association between cognitive plasticity and participants' age, taking into account individual level of cognitive functioning. In contrast to the results for cognitive plasticity and age, differences in cognitive plasticity were established in relation to participants' cognitive functioning, so that plasticity appears to be clearly associated not with age but with cognitive functioning. In this respect, the sample distribution shows that the group of old-old adults without plasticity presents a substantial increase in subjects with cognitive decline. This result initially seems to contradict the findings by Yang et al. [13], which indicate that cognitive plasticity continues to be present in the study sample independently participants' age and level of cognitive functioning. However, it should be noted that, in that study, both young-old and old-old adults presented a high level of cognitive functioning (matched with their surviving peers in the BASE study of the Berlin population, those rated as having a low level had a median rank at the 55th percentile and those with high cognitive functioning had a median rank at the 95th percentile). In contrast, the present study considered old adults with low MMSE scores (between 10 and 20 points). Our study also shows that the presence or absence of cognitive plasticity is not associated with age, but rather with the level of cognitive functioning. As a result, our old-old group had a high level of variability with regard to cognitive plasticity, as presumed by Baltes and Smith [15] and observed by Greenwood and Parasuraman [4]. However, these conclusions should be viewed with caution, given the limitations observed in the statistical power of the tests.

With regard to the third study's aim, which analysed QoL and cognitive variables in relation to cognitive plasticity in old age, our findings show that the best predictor of cognitive plasticity is level of cognitive functioning, rather than age. Together with cognitive functioning, the QoL variables included in this research, which also contributed to the prediction of cognitive plasticity in old age, were social integration and level of education, respectively. In other words, although our data show that cognitive functioning as measured by the MMSE is the principal factor to take into account when predicting cognitive plasticity, other factors such as social integration and education level may, although to a lesser extent, also help to explain the variability in cognitive plasticity shown in old age, as previous studies have found [4, 22, 23].

Lastly, we should point out that our findings should be treated with caution, in view of the characteristics of the study population (old adults living in sheltered accommodation in southern Spain). Accordingly, we hope that future studies will be able to corroborate our results and test their generalizability to other settings and cultures.

Conclusions

Our data show that there are no significant differences in cognitive plasticity between young-old and old-old adults performing a verbal memory task, but that differences do arise when their cognitive status is considered. Since the

proportion of subjects with cognitive decline increases from 80 years onward, cognitive functioning appears to be a determining factor in old-adults' cognitive plasticity. This factor, which is modulated by level of education and social integration, indicates that the combination of lifestyle factors and cognitive training probably has major effects on the cognitive functioning of old adults.

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Conflict of interest None.

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