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Cognitive Functioning in Older Adults: Relationship between Learning Potential and Specific Cognitive Domains

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Abstract

The aim of this study is to analyze the Learning Potential (LP) and its association to specific cognitive domains, health and sociodemographic conditions in older adults.

A total of 184 elders 60-years and older participated in this study, LP was assessed by using the Rey Auditory Verbal Learning Test. For specific cognitive domains a battery that included measurements of working andepisodic memory, meta-memory, processing speed, attention, executive function, language (semantic fluency and phonetic fluency), visuospatial skills. Socio-demographic and health data were also asked. Pearson´s correlation test and linear regression models were performed.

Results show significant correlation between Learning Potential performance and all domains of cognitive function. Results of the multiple regression analysis emerged on a significant model using the entered method: $F=57.69$, $p<.0005$. Executive function (phonetic fluency), language (sematic fluency), episodic memory, as well as education werethe most influential variables. The model explains 69.3% of the variance of LP; this interrelation set possible targets for cognitive interventions to promote learning potential, not only for preventing cognitive impairments, but also for promoting lifelong learning and healthy aging in older adults.

Key words: Learning Potential, cognitive function, aging, healthy aging, older adults.

1. Introduction

Population aging is occurring in all the major areas of the world. Globally, the share of older people (60 years and older) increased from 9 per cent in 1994 to 12 percent in 2014 and is expected to reach 21 percent by 2050 (United Nations, 2014). This growing population means growing demand for specialized, multidisciplinary attention appropriate to the circumstances of the elderly, also means the need of increasing opportunities to let people do what they value. Healthy Ageing is the option given by the World Health Organization to create environments and opportunities that enable people to age maintaining the functional ability that enables wellbeing in old age.

The WHO (2015) considers learning as one of the key domains for the Active Aging plandue to its influence on the environment and social contribution. Learning allows older adults to remain involved in activities that value, socialize and continue with their personal development, so it is natural that they still want and need to learn(Boulton-Lewis, 2010; WHO, 2015). Learning processes are influenced by intrinsic and extrinsic motivation, a suitable environment for the learning of this population group, the existence of prior knowledge and functional capacity, and cognitive status in aging (Boulton-Lewis, 2010).

Looking at the pattern of human cognition during normal aging, population-based cohort studies have shown cognitive decline in global cognitive function, as well as in domain-specific cognitive decline. Cullum et al. (2000), have found decline in orientation, language, memory, attention – calculation, praxis, abstract thought and perception over 4 years in a study including non-demented elderly people, in addition,

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Underline that the majority of participants showed evidence of significant decline in at least three cognitive domains. These normal cognitive changes associated to age occur in older adults withoutpathologies affecting memory or cognitive abilities, and do not interfere in their ability to participate in activities of daily living (Anderson, Murphy, & Troyer, 2012), and more important do not interfere with the capability to learn during aging but modify the techniques required.

Despite these changes, previous studies have demonstrated the existence of Learning Potential (LP) in aging, defined as the ability of people to access new strategies and solve problems beyond those already expressed (Villar, 2004). Learning Potential is the clinical expression of neuroplasticity, which is the capability of the brain to modify its structure according to the environmental demands (Fernández-Ballesteros, Zamarrón, Calero, & Tárraga, 2009). LP is the latent potential of the individual, the portion of intellectual that could be activated with additional energy and time (Fernández-Ballesteros, Zamarrón, Calero, & Tárraga, 2009).

Vygotsky is considered a pioneer in the subject when developing the concept of Next Development Zone, the distance between the level of real development, translated into the person's ability to solve a problem and the potential development, determined by the resolution of problems under the guidance of an adult (at children's case) or a more capable partner (Vygotsky, 1978). The learning potential allows the modifiability of thinking in the subject, this must be measured through an active process and never by an enumeration of existing skills, so it requires an active dynamic (Fernández Ballesteros, 1989; Sternberg & Grigorenko, 2002).

The measurement of Learning Potential could allow prediction of improvements in the lifelong learning process by subjecting it to an intervention. Linking learning potential to specific cognitive domains could help create specific programs to estimate cognition, assist older adults in creating new strategies for problem solving, and plays for creating new opportunities to healthy aging.

The most accepted technique for measuring Learning Potential consists of three moments. The pre-test consisting of the analysis of the subject's performance when applying a standard task. Subsequently, the subjects are trained with a material similar to that used in a standard way. Training where the evaluator provides a similar task and can provide clues that help the subject to adequately solve the task. Finally, the post test, where the standard task is evaluated again (Fernández-Ballesteros, 1989; Villar, 2004).

For this sense, the Rey Auditory Verbal Learning Test (Rey, 1964) has been considered an effective tool for measuring Learning Potential. The Rey Auditory Verbal Learning Test (RAVLT) is a neuropsychological assessment applicable for persons 16 years and older, designed as a list-learning paradigm in which the participant hears a list of 15 nouns and is asked to recall as many words from the list as possible during six trials, and after a 20 min delay, the participant is asked to again recall the words. It has been used widely used in clinical practice for detecting abnormal changes in cognitive functioning, the nature and severity of memory dysfunction, and to track changes in memory function over time. (Knight, McMahon, Green, & Skeaff, 2006). Besides, as it meets the three necessary moments for measuring Learning Potential, allows to demonstrate a learning curve during the trials and the gain score of potential. Hence, in this study Learning Potential is considered by given for the measurements derived from the RAVLT.

In older adults, Learning Potential has been related to age, Knight, McMahon, Green & Skeaff (2006), have found a consistent and statistically significant decline in LP as a function of age group. Also, LP has been related with ageing trajectories: successful, normal and pathological. These were determined by sociodemographic data, health, independence, cognitive abilities, perceived well-being and social participation. Gonzalez & Grasso (2018) found that successful ageing group obtained significantly higher scores both in comparison with the pathological ageing group and with the normal ageing group in LP and cognitive reserve.

The dynamic assessment used as a measure of Potential Learning has been explored in chronic diseases like diabetes type 2 in young and old-older adults. Yeung, Fischer & Dixon, (2009), found no significant influence of the illness on the word recall in the RAVLT, but and influence between both age groups, which contributes to previous findings.

Regarding cognitive domains, Learning Potential has been related to Premorbid IQ (Knight, McMahon, Green, & Skeaff, 2006). Also, has been closely related to memory performance (Estévez-González., Kulisevsky, Boltes, Otermín, & García-Sánchez, 2003)(Wang, Guo, Zhao, & Hong, 2012), Learning processes, have also been related to cognitive skills such as perception, short-term, long-term and work memory to process information properly (Kim & Merriam, 2004)(Boulton-Lewis, 2010).

The study of cognitive function in older adults is relevant because is considered an important risk factor for other pathologies in the old age, such as physical disability and dependence (McGuire, Ford, & Ajani, 2006)depression (Huang, Wang, Li, Xie, & Liu, 2011)and frailty (Robertson, Savva, Coen, & Kenny, 2014); but mainly because early pathological changes in cognitive function, are considered a preclinical state that may progress to dementia (Flicker, Ferris & Reisberg, 1991; Ritchie, Artero&Touchton, 2001; Tuokko&Frerichs, 2000).

To investigate the Learning Potential in older adults and its cognitive correlates, allows the opportunity to develop new training strategies for problem solving, based on personal cognitive resources; and also offers a guide to promote healthy aging by using better techniques for learning and teaching in old age.

The aim of this study is to analyze the Learning Potential and its association to specific cognitive domains, health and sociodemographic conditions on older adults.

2. Method

2.1 Participants

Participants were recruited in a Senior Center and community groups of older adults. A total of 201 older adults 60-years and older participants aged 60 years and older living in the community, were invited to participate. Written informed consent was obtained. Seven teen participants were excluded because they had cognitive impairment, determined by the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) according to the criteria for Mexican older adults standardized by age, gender and education (Arias-Merino, y otros, 2011). Total sample of n=184 were included in the study.

2.2 Assessment

Consenting participants, who met the inclusion criteria, were assessed by trained gerontology or psychology undergraduate students. The assessment was carried out in a face-to-face session; the battery comprised cognitive function and health test, as well as socio-demographic data as part of a comprehensive neuropsychological test battery. The test, and the associated domains are detailed in Table 1.

For the Rey Auditory Verbal Learning Test (Rey, 1964), participants were given a list of 15 unrelated words read aloud at rate of one per second repeated over five different trials, and then asked to repeat after each trial. The order of presentation of words remained fixed across trials. Score in each trial consisted in the number of correct words recalled in each trial. Trial six was considered as a measure of short-term memory. After a 20-min delay period, each participant was again required to recall the words (Trial 7), this score was considered as a measure for long-term memory. Other psychometric activities were carried out during the 20-min delay period.

Depressive symptomatology was assessed by the Geriatric Depression Scale (Yesavage, y otros, 1983). with scores ranging from 0–15, participants with a score >5 were considered as high depressive symptoms. Functional status was determined by the Instrumental Activities of Daily Living Scale IADL (Lawton & Brody, 1969), those reporting at least one difficulty on performing activities were considered as disability. In addition, participants informed on health characteristics: diabetes, hypertension, arthritis, chronic lung disease, stroke, heart disease, cancer, vascular disease.

Table 1. Neuropsychological test battery.

Cognitive Domain	Measurement	Test
Learning Potential Memory	Rey Auditory Verbal Learning Test	RAVLT (Rey, 1964)
Working memory	Digit span test backward	WAIS-IV (Wechsler, 1997).
Episodic	History Subtest, total score.	RivermeadBehavioural Memory Test RBMT Subtest (Wilson, Cockburn, & Baddeley, 1985).
Meta-memory	Perception of their own memory.	Self-report.
Processing speed	Digit Symbol-Coding	WAIS-IV (Wechsler, 1997)
Attention	TMT-A, total score	Trail Making Test A (Reitan& Wolfson, 1993).
Executive function	Phonetic fluency: FAS	Benton Controlled Word Association Test (COWA) (Benton &Hamsher, 1976).
	TMT-B total score	Trail Making Test B (Reitan& Wolfson, 1993).
Language	Semantic Fluency: Animals, fruits, vegetables	FAS (Spreen & Benton, 1969).
	Denomination task, subtest	NeuroPsi (Ostrosky-Solís, Ardila &Roselli, 1999).
Visuo-spatial skills	Block Design	WAIS-IV (Weschler, 1997).
Global cognitive function	Mini-mental State Examination (Folstein, 1975)	MMSE, adjusted by age, gender, and sex (Arias Merino et.al. 2011).

2.3 Statistical Analyses

The data were analyzed using Statistical Package for the Social Sciences version 18 software (Chicago, IL, USA). The data were processed to obtain proportions, means, and their standard deviations. Pearson´s correlation test and linear regression models using the entered method were performed ($p<.05$).

3. Results

The sociodemographic characteristics of the sample are presented in Table 2. The mean age was 72.03 (SD=6.97) years, mean years of education were 5.53 (SD=4.33) ranged from 0 to 19, were women 87%. Reported difficulties on IADL 19%, and 24.5% presented depressive symptomatology. Mean number of diseases was 1.59 (SD=1.18), only 14.1% reported no disease, while 27.2% had 3 or more, most frequent diseases were hypertension (54.9%), arthritis (34.8%) and diabetes (30.4%).

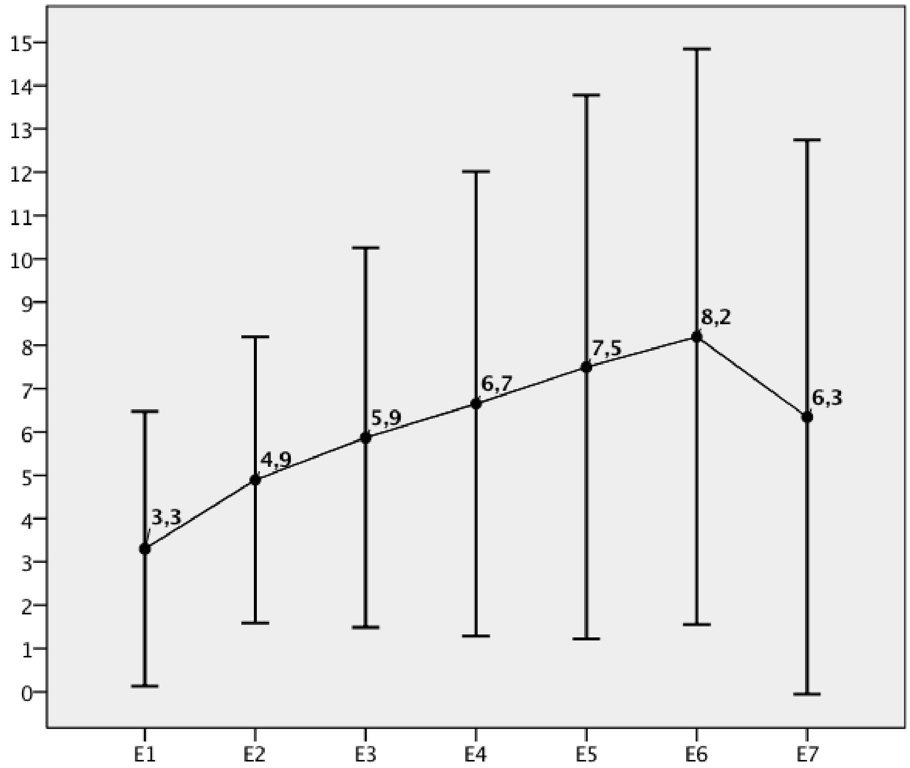
Table 2. Sociodemographic and health characteristics of the participants.

Variable	% (n= 184)
Age, years (mean 72.03, SD 6.97)	
60 – 64	14.1 (26)
65 – 69	27.7 (51)
70 – 74	22.3 (41)
75 – 79	21.2(39)
80 – 84	9.2 (17)
85 +	5.4 (10)
Education, years (mean 5.53, SD 4.33), range 0-19	
Sex	
women	87.0 (160)
men	13.0 (24)
IADL disability	19.0 (35)
Depressive symptomatology	24.5 (45)
Diseases, number (mean 1.59, SD 1.18)	
0	14.1 (26)
1	31.0 (57)
2	27.7 (51)
3 and more	27.2 (50)

SD= Standard Deviation, IADL= Instrumental Activities of Daily Living.

Performance of Learning Potential is showed in Figure 1, mean of words recalled and standard deviation are presented. It can be observed an increment in number of retained words from trial 1 to trial 6, and an expected decline in Trial 7.

Figure 1. Scores on Learning Potential (RAVLT essays) mean +- 1 Standard Deviation.



Results of correlation test shows significant correlation between Learning Potential performance and all domains of cognitive function (See Table 3). Age was negatively related to performance on Learning Potential and education had a significant positive relation.

Regarding health conditions, depressive symptomatology showed a trend to be negatively related to Learning Potential performance (p=.087), physical function was positively associated, while the number of diseases was not related.

Table 3. Learning potential performance correlations to cognitive domains, sociodemographic data and health conditions.

	Variable	**Pearson´s correlation**	**p=**
Cognitive Domains	Working memory	0.273	.000
	Episodic memory	0.427	.000
	Meta-memory	0.165	.026
	Processing speed	0.465	.000
	Attention	-0.410	.000
	Executive Function (TMT-B)	-0.184	.022
	Phonetic fluency	0.536	.000
	Semantic fluency	0.427	.000
	Denomination task	0.160	.031
	Visuospatial skills	0.273	.000
	Global cognitive function	0.372	.000
Sociodemographic data	Age	-0.359	.000
	Education	0.394	.000
Health conditions	Depressive symptomatology	-0.127	.087
	Number of diseases	-0.024	.749
	Physical Function	0.168	.023

MMSE= Minimental State Examination

Results of the multiple regression analysis emerged on a significant model using the entered method: F=90.88, p<.0005. The model explains 69.3% of the variance of Learning potential (Table 4). Predictor variables were executive function (phonetic fluency), language (sematic fluency), episodic memory, and education. Age, depressive symptomatology, physical function and diseases were not related with verbal learning performance.

Table 4. The unstandardised and standardised regression coefficients for the variables entered into the model.

Variable	B	SE B	β
Executive function (Phonetic fluency)	0.15	0.05	0.17**
Language (Semantic fluency)	-0.18	0.06	-0.18**
Episodic memory	0.23	0.13	0.09*
Education	0.26	0.11	0.12*

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

4. Discussion

Performance of Learning Potential is closely related to domains of cognitive function, specifically executive function (phonetic fluency), language (sematic fluency), episodic memory, as well as education. Health conditions such as number of diseases, depressive symptomatology and physical function was not related to Learning Potential performance. Age was not associated to Learning Potential performance.

Our study supports the hypothesis that cognitive performance is strongly related to intrinsic capabilities, experience and practice, more than age. In this sense there is evidence that cognitive scores increase over time more related to cohort effects and life expectancy than merely age (Rotrou et.al. 2013). Results are consistent with others studies were there was not found significant differences associated to age in measurement performance of RAVLT (Malloy-Diniz, Parreira-Lasmar, Rabelo-Gazinelli, Fuentes, & Salgado, 2007),although some others had reported that older adults generally require more effort for codification and recovery processes, and then performed worse in RAVLT than younger adults (Geffen, Moar, O'Hanlon, Clark, 1990; Bataller & Moral, 2006; Navarro & Calero, 2018).

It was also observed that performance in learning potential was not related to the number of comorbidities, but there was better performance in those with better functionality, coinciding with that described by Navarro & Calero (2018) and Gonzalez-Aguilar & Grasso (2018), who found that healthy older people showed better performance in task measurement as well as greater neuronal plasticity.

Regarding the education, other studies had also reported an association to RAVLT performance (Malloy-Diniz, Parreira-Lasmar, Rabelo-Gazinelli, Fuentes, & Salgado, 2007), reporting that education improves and maintains learning capabilities through the performance in RAVLT (Blachstein, Greenstein & Vakil, 2012; Query & Megran, 1983).

In terms of the positive relation that was found between Learning Potential and domains of cognitive function, other authors found it related to verbal memoryand cognitive reserve in older adults with different aging trajectories (Navarro & Calero, 2018); and also related tothe performance in executive function, language, semantic and phonologic fluency, and the performance in the clock-drawing test in older adults with mild cognitive impairment (Gonzalez-Aguilar & Grasso, 2018). Also, it was found an increment in performance of Learning Potential related to working memory, immediate memory, logic memory across time through an intervention of cognitive stimulation (Buiza et.al. 2008).

The contributions obtained in this study offer evidence of the important role of executive function (phonetic fluency), language (sematic fluency), episodic memory in the learning potential that has been cataloged as the clinical expression of neuroplasticity, at the same time that it has been linked to healthy and successful (Navarro & Calero, 2018).

The importance of literacy as a social debt to the older adults is reaffirmed, since it was a variable associated with better performance in learning potential. It also highlights the need for more flexible measurements and the inclusion of learning potential in neuropsychological evaluations in old age (Gonzalez & Grasso, 2018), as well as the generation of new teaching strategies and cognitive stimulation, especially of the functions that resulted in a statistically significant relationship, in order to develop skills for solving everyday problems that promote well-being and health in older adults with lower education.

Cognitive performance is a marker of the risk of neurodegenerative diseases among others, therefore a good functioning from its stimulation reduces the chances of suffering from this type of disease, which generates costs at the individual, social and economic level, therefore it is important to promote and consider for intervention all variables related to learning potential.

Finally, it is important to underline that in this study older adults showed Learning Potential, contrary to stereotyped ideas about older adults do not have the abilities to learn. Currently, learning potential takes on special importance in gerontological literature due to implies the recognition that older adults can respond adaptatively to cognitive demands that exceed one´s cognitive resources, reflecting the individual´s potential for improvement (Löven et.al. 2010), and demonstrate that older adults, at any age, can improve their performance after training (Joneset.al. 2006), even more is an indicator of cognitive plasticity referring brain modifiability and optimized intellectual performance (Navarro & Calero, 2018).

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