REVISTA IBEROAMERICANA DE PSICOLOGÍA Y SALUD

VOL 12. NÚMERO 2. JULIO 2021. 113 - 120.

ISSN: 2171-2069
https://doi.org/10.23923/j.rips.2021.02.049

Consejo General de la Psicología ESPAÑA

REVISTA IBEROAMERICANA DE PSICOLOGÍA Y SALUD

Revista Oficial de la Federación Iberoamericana de Asociaciones de Psicología (FIAP)
[Official Journal of the Latin-American Federation of Psychological Associations]

Memory of visual paired associates in healthy aging. A transcultural study

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• Recibido: 05 - 05 - 2021 • Aceptado: 07 - 06 - 2021 • Avance online: 12 - 07 - 2021

ABSTRACT. The present study contrasts performance in an immediate and delayed recall test across two aging populations without known neurological disorders from different cultural contexts. A total of 191 individuals, 97 Cubans and 94 Spaniards, participated. The age range was between 60 and 90 years (*M* = 70.6; *SD* = 6.8). The participants were evaluated with an immediate and a 30-minute delayed visual paired associates (VPA) test. Results showed no significant differences in the correct answers of the immediate and delayed recall depending on the nationality and gender of the participants. Age and educational level affected performance in immediate and delayed memory. A lower age and a higher level of education produced a better performance. In conclusion, the VPA test can be useful to assess memory across populations of different cultural contexts. Age negatively affected performance in immediate and delayed memory tasks in healthy aging. Educational level could be a protective factor, associated with the formation of the cognitive reserve.

KEYWORDS: Healthy aging, Cognitive decline, Cultural context, Episodic memory, Visual paired associates, Cognitive reserve.

Memoria de pares visuales asociados en el envejecimiento sano. Un estudio transcultural

RESUMEN. El presente estudio contrasta el rendimiento en una prueba de recuerdo inmediato y demorado en dos poblaciones envejecidas sin trastornos neurológicos conocidos de contextos culturales diferentes. Participaron 191 personas, 97 cubanos y 94 españoles. El rango de edad estuvo entre 60 y 90 años (*M* = 70.6; *DT* = 6.8). Los sujetos fueron evaluados mediante una prueba de pares visuales asociados (PVA) inmediata y demorada 30 minutos. No se encontraron diferencias significativas en las respuestas correctas del recuerdo inmediato y demorado en función de la nacionalidad o el sexo de los participantes. La edad y el nivel de escolaridad afectaron al rendimiento en memoria inmediata y demorada. Menor edad y mayor nivel de escolaridad produjeron mejor rendimiento. La prueba PVA puede ser útil para evaluar la memoria en poblaciones de contextos culturales diferentes. La edad afectó negativamente al rendimiento en tareas de memoria inmediata y demorada en el envejecimiento sano. El nivel educacional podría ser un factor protector, asociado a la formación de la reserva cognitiva.

PALABRAS CLAVE: Envejecimiento sano, Declinar cognitivo, Contexto cultural, Memoria episódica, Pares visuales asociados, Reserva

Although normal aging has been associated with the decline of certain abilities, it is still unknown precisely what are the neural bases and manifestations of normal cognitive decline associated with age, as well as the cognitive processes that remain unscathed.

In general, more is known about the diseased brain than the healthy brain. Studies on the diseased brain are performed within a continuum that ranges from the first signs of cognitive deficit to dementia. In the normal aging of the brain some structural and functional

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Citar como/Cite as: Álvarez, M. A., Cruz, T., Balmaseda, R., Gracia-Morilla, C., García-Morales, L., Fernández-Cahill, M. y Manzanero, A. L. (2021). Memory of visual paired associates in healthy aging. A transcultural study. *Revista Iberoamericana de Psicología y Salud, 12*(2), 113-120. https://doi.org/10.23923/j.rips.2021.02.049

changes have been identified such as cortical atrophy, diminution of neuronal size and number of connections, degeneration of synapses, and changes in white matter or in structural and functional connectivity both within and between neural networks (Wyss-Coray, 2016; Zonneveld et al., 2019). However, neural deterioration is not enough to explain all cognitive changes in healthy aging, because it is necessary to place them in the context of brain plasticity that will influence the appearance of individual differences during this process. The brain is structurally and functionally reorganized throughout life, including the stages during which aging occurs. Zonneveld et al. (2019) show that older adults with good cognitive performance compensate for neural decline with a plastic reorganization of neurocognitive networks. The most consistent data point towards a lower intra-network connectivity in healthy aging (segregation) and a greater inter-network connectivity (integration) (Sporns, 2013).

The normal decline of memory begins during adulthood and overlaps with other aspects of cognitive aging (Cansino, 2009). The maintenance of cognition at this stage can be achieved in two ways: avoiding diseases that affect the brain and by implementing efficient compensatory mechanisms. Genetic, epigenetic and lifestyle factors can influence aging and its effect on cognition, including external factors such as the physical, sensory, cognitive and social training to which the nervous system is subjected, thus identical deterioration cannot be expected for all human beings (Shafto et al., 2019).

One of the mechanisms proposed that can efficiently maintain cognition is the cognitive reserve (CR). CR, defined as the ability of an individual to counteract brain pathology by minimizing symptomatology, has been proposed as a factor that modifies or buffers the impact of brain pathology on cognitive function (Bettcher et al., 2019). Its neurophysiological substrate has two forms: a passive one related to the number of synapses or conserved neurons and an active one related to a more efficient processing or use of alternative brain networks. CR has frequently been measured through the years of education as some studies have shown an inverse relationship between the years of education and the risk of incidence and prevalence of dementia (Clouston et al., 2019). Importantly, high education was associated with slower decline in individuals with lesser atrophy but with faster decline in those with greater atrophy. Results suggest that education is an indicator of cognitive reserve in individuals with low levels of brain degeneration but the protective effect of higher education is rapidly depleted as brain degeneration progresses (Mungas et al., 2018). Other variables used as cognitive reserve markers are professional occupation or the realization of intellectual activities during leisure time (Lee & Chi, 2016).

Cross-cultural studies on memory in healthy aged populations allow us to isolate the influence of uncontrolled variables and are highly useful methodologically. However, the history of transcultural neuropsychology is brief and this field of knowledge is still very imprecise. A pending problem in the neurosciences is distinguishing between the neural mechanisms of human cognition sensitive to culture from those that are invariant between different cultures, as well as distinguishing the modulating cultural aspects from the constitutional ones in the neuronal substrates of human cognition (Chiao, Li, Turner, Lee-Tauler, & Pringle, 2017; Paige, Ksander, Johndro, & Gutchess, 2017).

A viable construct for this type of study is that of visual paired associates, which is a reliable indicator of explicit memory (Manns, Stark, & Squire, 2000). This paradigm has a coding phase and two recall phases, immediate and delayed, in such a way that both, encoding and retrieval processes and information consolidation are inferred. In Neuner et al.'s (2007) study, using this paradigm with fMRI on healthy participants, results showed the activation of a fronto-parieto-occipital network in both phases of recall and a left frontal accentuation for coding. As for subcortical areas, these authors found that the thalamus shows a bilateral activation during immediate recovery, but not during delayed recovery. The thalamus is part of an extended hypocampal-diencephalic system critical for coding and remembering new episodic information. They also found cerebellar activation in all conditions of the study due to its participation in higher cognitive processes.

Lockhart et al. (2012) found that the deficits associated with poor execution in episodic memory tasks using this paradigm of visual paired associates are related to white matter lesions in multiple pathways including the frontal and temporal cortex connections and the subcortical frontal white matter (e.g.: thalamic-frontal connections) that imply a disconnection and play a fundamental role in the memory differences observed across the elderly.

The present study aims to contrast the performance in an immediate and delayed recall test across two aged populations without any known neurological disorders from different cultural contexts.

METHOD

•PARTICIPANTS

A total of 191 individuals, 97 Cubans and 94 Spaniards (132 women and 59 men) were evaluated. The age range was between 60 and 90 years, with a mean age of 70.62 years (*SD* = 6.97). The educational level of the participants was: Primary (*N*=72), Secondary (*N*=42), Baccalaureate (*N*=51) and University (*N*=26).

The Cuban participants had a mean age of 71.31 years (*SD* = 7.49), and 67 of them were women. The educational level of the Cuban participants was: Primary (*N*=21), Secondary (*N*=17), Baccalaureate (*N*=35) and University (*N*=24). They were selected from an area of the Plaza de la Ciudad de La Habana municipality, where they periodically receive visits to control their health.

The Spanish participants had a mean age of 69.81 years (*SD* = 6.33), of which 65 were women. For these participants, the educational level was: Primary (*N*=51), Secondary (*N*=25), Baccalaureate (*N*=16) and University (*N*=2). They were recruited from the «El Parque» and «Concepción Arenal» senior centers, in Rivas-Vaciamadrid, where they participated in the activities.. This Spanish group was part of a sample of a previously published study (Cruz, García, Álvarez, & Manzanero, 2019). All participants were examined by neurologists or geriatricians to ensure they did not comply with the exclusion conditions of the study.

The inclusion criteria for both samples were: being aged over 60 years, having total physical and mental autonomy as well as willingness to participate in the study.

The exclusion criterion was the detection during the medical examination of any neurological disease, medical condition or use of substances that could compromise cognitive performance.

The Cuban and Spanish samples were studied cognitively by the same neuropsychologist in a room with adequate privacy, lighting and air conditioning conditions. All evaluation sessions were held in the morning with an approximate duration of 35 minutes. All participants signed an informed consent. The research complied with the principles of the Declaration of Helsinki for the study with humans, and was approved by the Ethic Committee at La Havana University. Each participant was given a summary of the results of their cognitive evaluation with suggestions for their physician.

•PROCEDURE

Participants were evaluated using a computerized version of visual paired associates test (VPA), inspired by the Wechsler Memory Scale-Revised (WMS) test for cognitive evaluation of the elderly (Cruz et al., 2019; Cullum, Butters, Tröster, & Salmon, 1990). The test has a coding phase and two recall phases (immediate and delayed). The coding phase is composed of three trials. In each trial, six pairs of colors and abstract figures in black and white (125 x 80 pixels, 7 x 4.5 cm for each figure and each color) are presented consecutively, on a gray background, during 6000 ms of visualization with 1000 ms Inter-stimulus interval. In the immediate recall phase, the six colors are presented simultaneously and continuously, while the abstract figures follow each other in random order, during 6000 ms of visualization each. The task of the participants is to identify what color is associated with each figure. After 30 min, in the delayed recall phase, the six colors and the random succession of abstract figures are presented. Participants must re-identify which color was associated with each figure. The variables recorded are correct answers in both recall phases.

•DATA ANALYSES

The statistical analyses performed were a General Linear Model, ANOVA, and Pearson (bilateral) correlations. The independents variables were gender, time delay, age and educational level, and the dependent variable was VPA recall.

RESULTS

The first result is that time delay affects the correct recall in VPA test, $F(1,190) = 127.191$, $p = .000$, $\eta^2 = .401$. Performance in immediate time ($M = 3.90$, $SD = 3.09$) was better than in delayed time ($M = 1.80$, $SD = 1.81$).

Interaction effects were analysed between delay and the other variables. However, no main effects for nationality, $F(1,189) = 0.949$, $p = .33$, $\eta^2 = .005$, or interaction effects for nationality and delay, $F(1,189) = 0.602$, $p = .44$, $\eta^2 = .003$, were found (see Table 1).

Gender did not affect recall, $F(1,189) = 1.674$, $p = .19$, $\eta^2 = .009$, nor interaction between gender and delay, $F(1,189) = 0.545$, $p = .46$, $\eta^2 = .003$ (see Table 2).

Education significantly affected performance in VPA test, $F(3,187) = 6.956$, $p < .00$, $\eta^2 = .100$. Yet the interaction between education and delay were not significant, $F(1,187) = 1.384$, $p = .25$, $\eta^2 = .022$ (see Table 3).

A Scheffe post hoc test was carried out to determine differences between the different educational levels during the immediate and delayed recall. As can be seen, the participants with Primary educational level obtained lower scores than participants with Baccalaureates, Scheffe = -1.49, $p = .002$; and than participants with University level, Scheffe = -1.69, $p = .007$. No other differences were found (see Figure 1).

Table 1

Mean values (and standard deviations) in correct responses for immediate and delayed recall for the Spaniard and Cuban samples

	Spaniard	Cuban
Immediate recall	3.67 (3.23)	4.12 (2.95)
Delayed recall	1.71 (1.98)	1.88 (1.64)

Table 2

Mean values (and standard deviations) in correct responses for immediate and delayed recall for men and women

	Men	Women
Immediate recall	3.49 (3.11)	4.08 (3.08)
Delayed recall	1.59 (1.51)	1.89 (1.93)

Table 3

Mean values (and standard deviations) in correct responses for immediate and delayed recall according to educational level

	Primary	Secondary	Baccalaureate	University
Immediate recall	2.89 (2.15)	3.88 (3.45)	4.80 (2.61)	4.96 (4.56)
Delayed recall	1.15 (1.52)	1.98 (1.56)	2.22 (2.01)	2.46 (2.04)

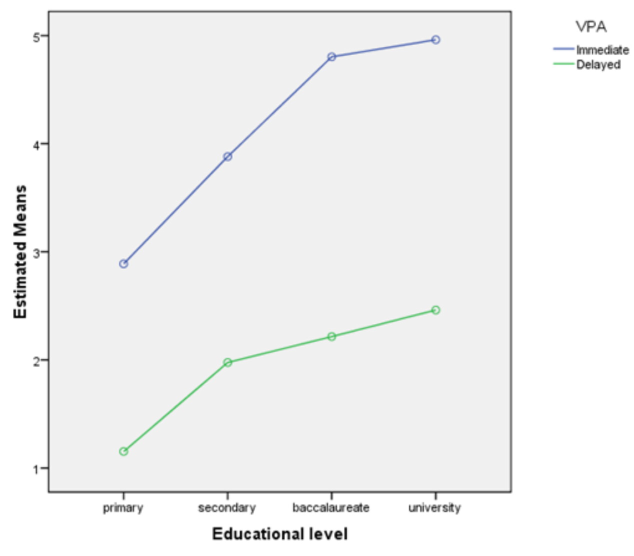

Figure-1: Relationship between educational level and correct answers in the immediate and delayed recall.

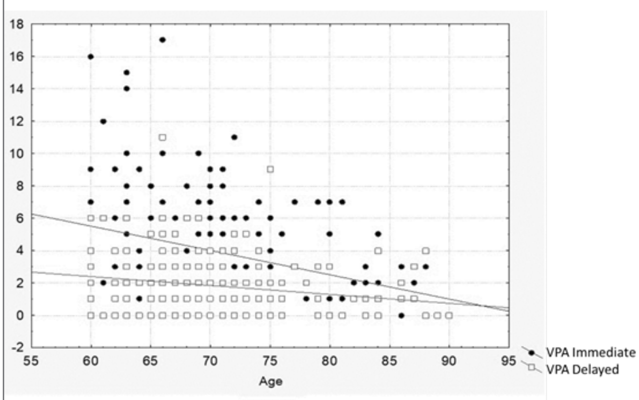

Figure-2: Scores of immediate VPA (black dots) and delayed VPA (white squares) according to age.

Finally, Pearson r (bilateral) correlations were analyzed to show the effects of age on performance in immediate, and delayed recall. Results showed that age affected both performances. With increasing age of the participants, their performance on tests decreased significantly in immediate recall, $r(N = 191) = -.338$, $p < .000$; and in delayed recall, $r(N = 191) = -.212$, $p = .003$.

As can be seen in Figure 2, the main differences depending on the delay are observed for the younger participants, with the VPA performance being equalized in those of older age because of a floor effect; that is, the older participants were not able to perform the task either immediately or delayed.

DISCUSSION AND CONCLUSIONS

The first element to discuss is the homogeneity of the responses of the two samples of different cultural contexts (understanding culture as habits and lifestyles, nutrition, idiosyncrasy). Regarding the relative independence of the cultural context in the performance of neuropsychological tests, previous studies have found that sociodemographic factors have an influence of less than 10% (Saykin et al., 1995) and studies have described brain regions in which the neural activity is the same across different cultures.

The similar results of the Spanish and Cuban scores may be due to two non-exclusive factors: a) the robustness of the visual paired associates in terms of their neural determinism and b) the existence of a solid language and cultural community between both countries capable of establishing similar patterns of behavior that manifest in basic cognitive variations. The stimuli used in VPA have a low cultural saturation, are abstract, nonverbal figures without any symbolic value recognized in the cultural contexts studied. On the other hand, there is a theory that suggests that the variable that governs the impact of culture on performance during tests is the cognitive resources demand (Park, 2002). In this sense, the tasks that demand cognitive processes such as processing speed, working memory and other fluid skills can show convergence in their execution across cultures in advanced ages. Through functional imaging studies, it is known that older adults have greater frontal activity and of hemispheres to perform tasks of this type while young people recruit regions of a specific hemisphere depending on whether the task is verbal or visuo-spatial (Yocota et al., 2000). These data suggest that there may be stimuli differentiated activation patterns of as a function of culture, but these differ less and less with increasing age (Reuter-Lorenz et al., 2000).

With respect to the decrease in the number of delayed correct answers in comparison with the immediate ones, their range is not different from that reported in this WMS test for patients older than 75 years (proportion of 2.2), thus it cannot be considered an indicator of cognitive deficit (Cullum et al., 1990).

On the other hand, the correlation coefficients of age with the correct immediate and delayed answers were also not different. This suggests that aging does not establish a different trend between both responses, but rather that the smaller number of correct responses maintains a stable pattern. This is probably due to a ceiling effect of the test greater than aging in this age range. Several studies have shown that elderly people adequately execute memory tasks that require little cognitive effort (such as this task in its first phase of recall) or are developed in a familiar spatial context, while their execution decreases in tasks that require more effort (Cansino, 2009; Robin, Garzon, & Moscovitch, 2019). The atrophy in medial temporal regions that occurs in the elderly could explain the decrease in the activation of these areas during visual tasks and their poor performance in memory tasks compared to young adults. With aging, atrophy also occurs in other brain areas, such as the prefrontal cortex, which modify the connectivity between the cerebral medial regions and the rest of the brain (Dennis et al., 2008) and thus, contribute to the deterioration of episodic memory.

Regarding the effect of education, the areas most likely involved in the immediate recall are parahippocampal (extended hippocampal-diencephalic system), whicht are more active in the recognition of new configurations than those already known (Sadeh, Chen, Goshen-Gottstein, & Moscovitch, 2019). However, the delayed phase of the test depends mainly on the fronto-parieto-occipital network and the cerebellum (Neuner et al., 2007), thus it is necessary to formulate a hypothesis of the underlying mechanism. On the other hand, O`Shea et al. (2018) found that higher educational attainment in conjunction with greater hippocampal volumes (total, left, and right) was associated with better delayed but not immediate recall performances, where the positive association between hippocampal volumes and delayed recall was greatest in those with more years of education, which is consistent with our results.

In the elderly, associated with cortico-subcortical atrophy, there is a decrease in the connections between the temporal medial regions and posterior regions and an increase with the prefrontal areas, known as PASA (*posterior-anterior shift with aging*) (Dennis et al., 2008) and which has been recognized as a functional compensation.

The effect of education on this test could be explained by the action of an executive component that determines better coding or recognition strategies and that may be related to the formation of a greater ability for cognitive reserve (CR) (Balduino et al., 2019; Delgado-Losada et al., 2019; Stern, 2009).

Scarmeas and Stern (2003) found differences in brain reorganization based on CR when studying brain activation through PET in 17 young people and 19 healthy elderly people while performing different memory tasks.

Some studies (Rodriguez, Zheng, & Chui, 2019) conclude that the protective effect of education on cognitive decline has been strongly contrasted but that it could depend on the measured cognitive ability. Ardila, Ostrosky-Solis, Rosselli, and Gomez (2000) studied 806 individuals divided into age groups and 4 different levels of education using the NEUROPSI battery and found that the effect of education was different depending on the cognitive domain. In some subtests, education explained one third of the variance and in others less than 1%. In about half of the subtests, education explained 20% of the variance. Therefore, the authors concluded that the effect of education is not homogeneous for all cognitive domains.

The effects of education on episodic memory are generally weak. There are studies that relate cognitive training to education, finding that frequent cognitive activity can compensate for a low educational level in episodic memory tasks. Thus, Lanchman and Agrigoroaei (2010) studied 3343 individuals and found that those with a lower educational level had worse cognitive performance, but those who were frequently involved in cognitive activities, rather than physical exercise, showed compensatory benefits in episodic memory.

Despite these data, the responsible mechanism that explains how these factors (CR, education, cognitive activities) reduce the risk of cognitive decline remains to be discovered.

Finally, no influence of the gender variable was found. This is not consistent with studies that find a female advantage for more verbal tasks and a male advantage for more spatial tasks, such as abstract images. However, studies have found that these differences are smaller in childhood and old age than for other ages, which may be in line with our work when studying the aging population (Asperholm et al., 2019).

• LIMITATIONS

One limitation to this study is that we did not administer a screening cognitive test or some short cognitive scale to rule out mild cognitive impairment or early stages of pathological cerebral aging to ensure that the sample did not have a cognitive deterioration beyond the cognitive decline expected by age.

- **Conflict of interest.**

The authors declare no conflict of interest.

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