Multivariate profile analysis applied to the neuropsychological comparison

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Abstract:
Background:Within the geriatric cognitive assessment is the neuropsychological assessment, which provides a set of instruments designed with the specific purpose of evaluating cognitive processes in people. The multivariate profile analysis is a statistical procedure that allows the comparison of profiles that are elaborated from variables measured in one or more groups.
Aim:To compare the neuropsychological tests performance of older adults and university students through multivariate profile analysis.
Materials and Methods: A comparative study was carried out with 14 older adults and 19 college students from Xalapa-Veracruz. The Wechsler Adult Intelligence Scale-IV (WAIS-IV) and the NEUROPSI Atención-Memoria (Attention and Memory) battery were used to obtain indicators of the neuropsychological processes. The statistical analysis was performed with SPSS Statistics Version 23 software for MacOS.
Results: The multivariate profile analysis showed that there are no significant differences between the profiles of the groups.
Conclusion: The neuropsychological characteristics of the groups were quantitatively similar. The educational level, the occupational complexity and the socioeconomic status of the participating older adults can have a positive impact on their cognitive state, favoring their cognitive reserve to face the neuropsychological changes associated with aging.
Key Word:Aging; Neuropsychology; College students; Cognition; Statistical method.

I.   INTRODUCTION

Multivariate analysis allows to study, analyze and interpret the data resulting from the observation of more than one variable in the same object or unit of study. The information studied in multivariate analysis is multidimensional in nature, so that geometry, matrix calculation and multivariate distributions are necessary for its analysis (Cuadras, 2014; Härdle&Simar, 2003; Montanero, 2015; Rencher, 2002).

Multivariate profile analysis is commonly used when looking to compare a vector of variables in different groups to analyze the effect that the group has on some characteristics, it can also be used in the case of repeated measures. In this analysis, the graphs based on the data averages are used to make visual comparisons between the average profiles of each group; the data is plotted using the horizontal axis for the dimensions or variables measured, and the vertical axis for the score corresponding to the group average in the variables. Each average score is linked to that of the following variable using a line to create a profile. In addition to visual analysis, hypothesis tests (described in **Statistical analysis** section) are also used to discern the significance of the patterns or effects observed in previously plotted profiles (Rencher, 2002).

Within the geriatric cognitive assessment, neuropsychological evaluation can be considered as a tool that provides the clinician with a set of instruments or batteries designed for the specific purpose of analyzing the state of the patient's cognitive processes. The use of these instruments allows the comparison of the results obtained by people with a set of standardized normative data for the population.

With the instruments of neuropsychological evaluation, values are assigned to the performance of the individual, this allows to analyze how their execution is modified in different stages of their life. Therefore, neuropsychological evaluation allows characterizing the cognitive strengths and weaknesses of a person or a group of people.Once the cognitive functioning characteristics of the person have been described, the cognitive domains that are affected and which are preserved must be identified, this can be compared with the premorbid

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characteristics to make inferences about their functioning, which allows develop a diagnosis and determine a treatment (Drake, 2013).

The cognitive processes that are studied in neuropsychological assessment are functional properties of individuals and their analysis is carried out based on the observation of behavior. Broadly, four main classes of cognitive functions have been described, the receptive ones that include the skills to select, acquire, classify and integrate stimuli present in the context; those of memory and learning that are responsible for the storage and retrieval of information; those of thought related to the organization and mental reorganization; and expressive ones, which are the means by which we communicate. Although each function can be conceptually distinguished, in reality the cognitive functions must work together, so the evaluation must be both specific, when there is a specific functional failure, as well as when assessing the affected process in interaction with the other processes (Lezak, Howieson, Bigler &Tranel, 2012).

In Mexico, the *Consejo Nacional de Población* (CONAPO) estimated that, in 2015, of the 121 million people living in the country, 12 million were over 60 years old. Similarly, this institution foresees that by 2030 the population of older adults will be equivalent to 14% of the national population (*Consejo Nacional de Población*[CONAPO], 2016).

Population growth over 60 years leads to the emergence of new demands and considerations for the comprehensive care of the elderly (Jara, 2007; Palloni, Mceniry, Wong, &Pelaez, 2005). Knowing the cognitive status of the population allows for a reference framework to develop interventions that reduce the problems of said population (Rayón, Juárez, &Muggenburg, 2015). It then becomes important to investigate the biological, psychological, social, economic, health and political processes of the elderly population to prevent negative conditions that may affect them, and, in turn, generate accompanying policies that allow them to adequately transit through this stage of life (Quevedo, 2008).

As mentioned, the increase in the average life (in the third age) also implies that chronic degenerative diseases are present for longer periods of time, which leads to a greater expenditure of both economic and human resources in the care of these patients and their poor quality of life. Finding out the prevalence of cognitive deterioration in the population, studying the factors that precede it, as well as those associated with its prevention will allow the creation of strategies that reduce the severity of the complications of this condition (Mias, Querejeta, & Masih, 2007).

As described above, the objective of this work was to compare the performance in neuropsychological tests of older adults and university students through multivariate profile analysis. The analysis was approached under the hypothesis that the performance of older adults in neuropsychological tests is lower than that of university students.

II. MATERIAL AND METHODS

Study Design:A prospective research of quantitative, cross-sectional and correlational type was carried out.
Study Location: Laboratorio de Psicobiología, at Universidad Veracruzana, Xalapa, México.

Subjects & selection method: In this research, 44 volunteers participated and were divided into two groups: one of the old age participants and the other of university students. The first group was formed by 17 older adults, of which three were excluded, being made up of 14 participants. The second group was formed by 27 first-year university graduates, of which eight participants were excluded, being made up of 19 participants. The excluded participants where those who did not complete the evaluations.

Instruments

The Wechsler Adult Intelligence Scale (WAIS-IV), the Neuropsi Attention-Memory, the Mini-Mental State Examination (MMSE), the Beck Anxiety Inventory and the Yesavage Geriatric Depression Scale were used; For comparisons using multivariate profile analysis, the scores of the WAIS-IV and Neuropsi indexes were considered.

The Wechsler Adult Intelligence Scale-IV is an instrument that assesses cognitive ability from 16 to 90 years of age, based on the Verbal Comprehension, Perceptual Reasoning, Working Memory and Processing Speed. For the analysis, the scores obtained in each index were considered.The cut-off points of the WAIS-IV are: Extremely low from 0 to 69, Borderline from 70 to 79, Below average from 80 to 89, Average from 90 to 109, Above average from 110 to 119, Higher from 120 to 129 and much higher than 130 and up(Wechsler, 2014).

Similarly, the Neuropsi Attention-Memory neuropsychological battery makes it possible to assess attentional and memory processes, has normative data from 6 to 85 years and with scoring criteria depending on the schooling of the participant; The cut-off points of the Neuropsi Attention-Memory are: Severe alteration less than 69, Slight alteration from 70 to 84, Normal from 85 to 115 and Normal high from 116 onwards (Ostrosky-Solís, Gómez, Matute, Roselli, Ardila, &Pineda, 2012).

The group of older adults was also assessed with the MMSE to detect signs of cognitive impairment, which is composed of 6 areas that are: Temporary orientation, Spatial orientation, Fixation (immediate recall), Attention (calculation), Deferred memory and Language (Folstein, Folstein, &Folstein, 2010) and complemented by the Beck Anxiety Inventory and the Yesavage Geriatric Depression Scale.

Beck's Anxiety Inventory was used to determine the level of anxiety; it is a self-report test where the evaluated must select on a scale how much was affected by each of the 21 anxiety symptoms in previous weeks (Steer & Beck, 1997), the interpretation of the scores is made from three points cutting A score between zero and seven is interpreted as a minimum level of anxiety, from eight to 15 mild anxiety, from 16 to 25 moderate anxiety and>25 severe anxiety.

On the other hand, the Yesavage Geriatric Depression Scale of 30 items was applied to detect the presence of depressive symptomatology, it is a self-administered questionnaire where the evaluated must respond on a dichotomous scale (yes or no) depending on how they felt in the In recent weeks, to each of the questions that the scale presents (Sheikh &Yesavage, 1986), the range of scores ranges from zero to 30 in which the higher scores suggest high risks of depression and are interpreted from three points cutting A score between zero and 10 is interpreted as normal, from 11 to 14 mild depression and>14 moderate depression.

Procedure methodology

The neuropsychological profiles of the participants were obtained by means of the aforementioned tests. This was carried out through a three session assessment procedure, each lasting 90 minutes on average; the ethical principles for medical research in human beings established in the Declaration of Helsinki were followed (World Medical Association, 2013). Participants were given the results of the assessment and suggestions to favor the cognitive processes evaluated.

In the first session the aims and characteristics of the research was explained tothe participants; those who accepted signed an informed consent letter; a clinical history was made in which general, socioeconomic and health data were collected; older adults answered the Beck Anxiety Inventory, the Yesavage Geriatric Depression Scale and the MMSE. In the case of university students, an interview was conducted to gather information regarding the presence of symptoms of depression and anxiety.

In the second session, the Attention, Memory, and Executive Functions processes were evaluated with the Neuropsi Attention-Memory instrument. In the third session, Processing Speed, Working Memory, Perceptual Reasoning, Verbal Comprehension and Intelligence with WAIS-IV were assessed.

Statistical analysis

The groups were characterized using descriptive statistics for the variables: age, sex, occupation and schooling. For the group of older adults, in addition to the previous variables, the MMSE, anxiety and depression scores were described.

The assumptions needed to perform the multivariate analysis of profiles were verified with the Mardia test that assesses multivariate normality and the M-Box test that assesses the equality of covariance matrices.

The multivariate analysis of profiles tests three statistical hypotheses: 1) of parallelism, in which it is assessed whether the different segments of the profiles are parallel or equidistant between the groups and is defined in terms of the slopes of the lines that exist between the average scores of the different variables that make up the profiles; 2) of horizontality, in which it is checked if the average scores obtained in the different variables that make up a profile are identical, that is, the groups of participants obtain the same average score in all the measured variables; 3) of coincidence, in which it is analyzed if one of the groups has average scores higher than the other in the variables assessed, this hypothesis corresponds to the effect of belonging to a group.

Subsequently, a post-hoc analysis of the comparison of means was carried out to assess whether there were differences between the cognitive processes evaluated.

III. RESULTS

For the group of older adults, the average age was 70.8 (SD = 7.9 years). The minimum age was 60 and the maximum was 82, covering a range of 22 years. For the group of university students, the average age was 18.8 years (SD = 1.2). The minimum age was 17 and the maximum was 22, covering a range of five years.Regarding gender, the group of older adults consisted of 12 women and two men. The university student was made up of 14 women and five men.

The most prevalent occupation in the group of older adults was "Housewife" with eight people, followed by "Retired" with three people and with one person in the categories of "Administrative employee", "Writer" and "Teacher" respectively.

Regarding the schooling of the elderly, six participants had studies at the bachelor's level of which four were from the educational area, three people with elementary school completed, four with highschool and one with master's degree.

In the MMSE, 80% of the elderly were in the Normal range, 13.3% obtained a score corresponding to Pathological Suspicion and 6.6% was in Deterioration. In Beck's Anxiety Inventory, 73.3% was found in the Minimum Anxiety range, 13.3% in Moderate Anxiety and 13.3% in Severe Anxiety. In Yesavage's Geriatric Depression Scale, 53.3% were in the Normal range, 20% in Mild Depression and 26.6% obtained scores that were classified as Moderate Depression.

In the Mardia test to assess multivariate normality, it was found that all matrices met the criteria of multivariate normality: WAIS-IV matrix of the group of older adults [df = 7, 22; p = 0.29], matrix of WAIS-IV of the group of university students [df = 4, 21; p = 0.76], Neuropsi matrix of the elderly group [df = 4, 17; p = 0.16], Neuropsi matrix of the group of university students [df= 4, 13; p = 0.17].

On the other hand, the equality test of covariance matrices resulted in WAIS-IV [M = 19.86, $F_{(10, 36)}$ = 1.69, p = 0.076]; and in Neuropsi Attention-Memory [M = 4.33, $F_{(3, 21)}$ = 1.32, p = 0.264]. Therefore, it was considered that the assumption of equality of matrices of variances and covariances was fulfilled and the multivariate analysis of profiles was carried out.

In the WAIS-IV profile analysis, a value [Pillai's Trace = .430, $F_{(3, 29)}$ = 7.29, p = 0.001] was found in the Horizontality test. In the Parallelism test, a value [Pillai's Trace = .087, $F_{(3, 29)}$ = 0.921, p = 0.443] was observed. A value [$F_{(1, 31)}$ = .002, p = 0.968] was found in the Coincidence test or equality of means between groups.

The profile graph allowed visual confirmation of the tests performed (Figure 1). It was observed that the profiles of the group of older adults and the group of university students had similar behaviors in most of the profile segments (WAIS-IV index scores decreased or increased similarly in both groups) which resulted in no rejection of the hypothesis of parallelism; the fact that the means of both profiles encountered a very subtle variation in the score resulted in no rejection for the coincidence hypothesis; Finally, because the scores were different in the four WAIS-IV indices in both groups, the horizontality hypothesis was rejected.
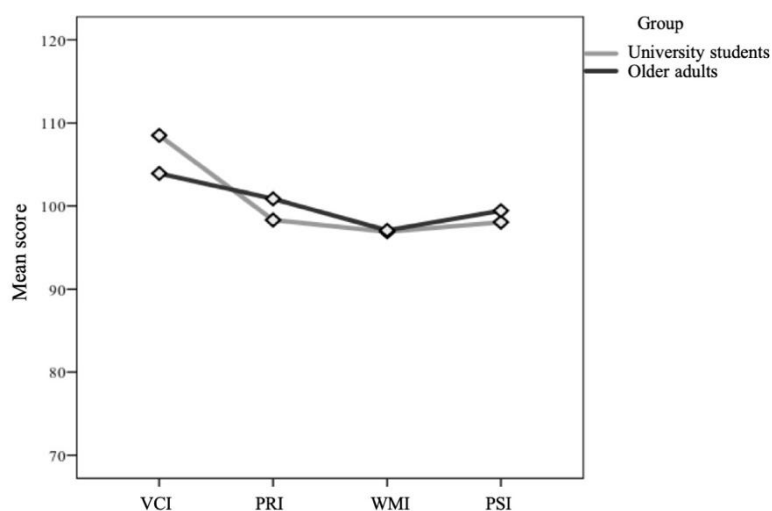

Figure 1. WAIS-IV index profiles. VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index.

As for the analysis from the Attention-Memory Neuropsi, a value [Pillai's Trace = 0.085, $F_{(1, 29)}$ = 2.70, p = 0.111] was found in the Horizontality test. In the Parallelism test, a value [Pillai's Trace = 0.018, $F_{(1, 29)}$ = 0.538, p = 0.469] was observed. A value [$F_{(1, 29)}$ = .110, p = 0.742] was found in the Coincidence test or equality of means between groups.

The profile chart allowed visual confirmation of the tests performed (see Figure 2). It was observed that the profiles elaborated from the Neuropsi Attention-Memory of the group of older adults and of the group of university students had a similar tendency to decrease in the memory area which resulted in no rejection for the parallelism hypothesis; the fact that the means of both profiles were equivalent resulted in no rejection for the coincidence hypothesis; finally, because there was no strong variation between the averages of the two areas evaluated in this profile, the horizontal hypothesis was not rejected.
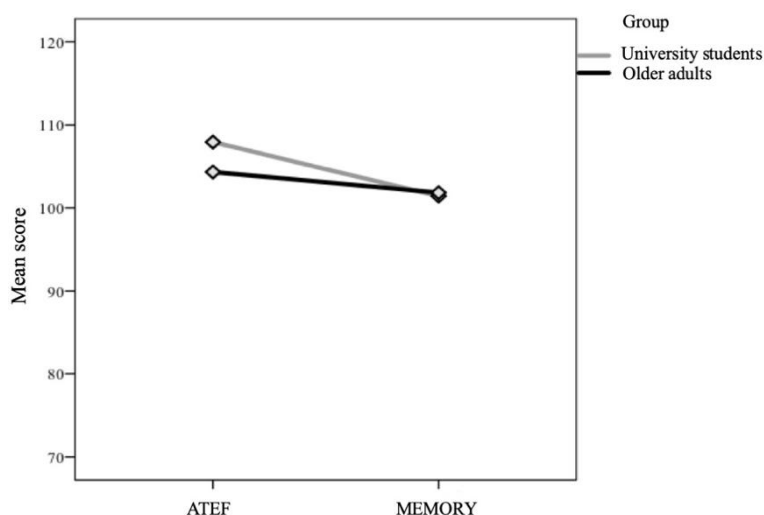
Figure 2. Profiles of the Neuropsi Attention-Memory areas. ATEF = Attention and Executive Functions.

In the results of the post-hoc analysis of the comparison of means, significant differences were found that are due to higher average scores in the Verbal Comprehension Index compared to the Working Memory Index and the Processing Speed Index; no significant differences were found between the areas measured from Neuropsi Attention-Memory (see Table 1).

Table 1 Pairwise comparisons (I - J) of neuropsychological variables

(I)	(J)	Mean difference (I-J)	Standard error	Sig. [a]	95% CI IL	95% CI UL
VCI	PRI	6.64	2.37	.052	-.047	13.32
	WMI	9.24*	2.05	.001	3.45	15.03
	PSI	7.48*	1.85	.002	2.26	12.71
PRI	VCI	-6.64	2.37	.052	-13.32	.047
	WMI	2.60	2.09	1.000	-3.30	8.50
	PSI	.84	1.81	1.000	-4.26	5.95
WMI	VCI	-9.24*	2.05	.001	-15.03	-3.45
	PRI	-2.60	2.09	1.000	-8.50	3.30
	PSI	-1.75	1.76	1.000	-6.73	3.22
PSI	VCI	-7.48*	1.85	.002	-12.71	-2.26
	PRI	-.84	1.81	1.000	-5.95	4.26
	WMI	1.75	1.76	1.000	-3.22	6.73
ATEF	Memory	4.51	2.74	.111	-1.10	10.12

*Note: CI = Confidence Interval; IL = Inferior limit; UL = Upper Limit; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index; WMI = Working Memory Index; PSI = Processing Speed Index; ATEF = Attention and Executive Functions; [a] Adjusted for Bonferroni comparisons; * Significant mean difference in level p <.05*

IV. DISCUSSION

The aim of the research was fulfilled because the neuropsychological profiles between older adults and university students were compared using multivariate profile analysis, a technique that allowed comparisons to be made together of the variables measured with the WAIS-IV and the Neuropsi Attention-Memory. In this analysis it was found that in the profile prepared from the WAIS-IV there were no differences in the average scores of the variables between the groups and that both profiles presented a parallel behavior, the above suggested that the average scores in the measured variables tended to decrease or increase in both groups in a similar way, on the other hand, in both groups the horizontal hypothesis was rejected, this indicated that the average scores were different between the rates of Verbal Comprehension, Perceptual Reasoning, Working Memory and Speed of Processing.

Regarding the analysis of the Neuropsi Attention-Memory scores, results were similar to those of the WAIS-IV indexes; no differences were observed between the average scores of the variables between groups, and the behavior of the profiles was also parallel, however, in the Neuropsi Attention-Memory profiles the horizontality hypothesis of the multivariate analysis of profiles was not rejected. This allowed us to conclude that, in the case of Neuropsi Attention-Memory, there were no differences between the average Attention and Executive and Memory Functions scores between the two groups.

The hypothesis stated for this research was not fulfilled because we found no differences in the cognitive performances of older adults and university students.On the other hand, the failure to reject the coincidence hypothesis of the multivariate profile analysis meant that in both older adults and university students, similar average scores were found in neuropsychological variables, which may indicate that the neuropsychological processes evaluated in older adults are at an optimum level for their age, this could be attributed to the educational level that in most of the participants was a bachelor's degree and even a postgraduate degree; and to socioeconomic income, which fluctuated from two to seven minimum wages. Regarding occupational complexity, most participants work as housewives and as teachers, both activities require physical and cognitive effort.

Regarding cognitive and affective processes, low prevalence of cognitive impairment was observed according the MMSE, and low levels of anxiety according to Beck's Anxiety Inventory. The set of factors described so far can favor in the participants adequate levels of cognitive reserve, which would allow them to face the cognitive changes associated with aging, resulting in the lack of significant differences reported in the results of this research.

In the university students, average scores were observed both in the WAIS-IV and in the Attention-Memory Neuropsi, so that their cognitive processes are at adequate levels to meet the demands of university studies. The highest score of all the processes assessed was found in the Verbal Comprehension Index, which is known to be related to the verbal processing of information, the relationship between words and sentences, the capacity for abstraction, and general knowledge of the context in the that unfold; these skills are important at university level because much of the learning will depend on the ability of students to take an active role in reading academic texts, recognize their main ideas, identify the author's intention, suppress ideas that do not they are relevant to make sense of the writing, and use their previous knowledge to integrate a personal position before the texts that they read.

In turn, profiling is a common practice in psychological measurement, we can find it in the various branches of psychology, for example, when creating personality, organizational, or criminal profiles, among others. In addition, the constructs studied in psychology are often composed of multiple characteristics or areas, so the use of multivariate techniques allows us to get closer to reality (compared to univariate techniques), by analyzing all these characteristics together.

Although we didn't find significant differences, this research showed that multivariate profile analysis is a useful tool in the study of neuropsychological variables, since it allowed us to compare the neuropsychological profile of several groups regarding their cognitive ability components, attention and memory.

V. CONCLUSION

The neuropsychological characteristics of the groups were quantitatively similar. The educational level, the occupational complexity and the socioeconomic status of the participating older adults can have a positive impact on their cognitive state, favoring their cognitive reserve to face the neuropsychological changes associated with aging.

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