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Cognitive Reserve in Older Adults: A Cluster Analysis

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ABSTRACT – Cognitive reserve (CR) is a construct generally associated with neurodegenerative diseases in aging. The aim of this paper was to examine the CR profiles of older adults at different stages of their lifespan and evaluate the importance of: (a) gender and CR; and (b) CR, cognition, and symptoms of depression. A sample of 195 older adults volunteered to participate in the study, and a cluster analysis was carried out on their responses in terms of the Cognitive Reserve Scale. The cluster analysis depicted two different profiles. Furthermore, women had a better CR than men. The results provide an important contribution to understanding the variables related to the CR construct.

KEYWORDS: Cognitive reserve, Aging, Self report, Life cycle Stages, Aged

Reserva Cognitiva em Adultos Idosos: Uma Análise de Cluster

RESUMO – A reserva cognitiva (RC) é um construto geralmente associado a doenças neurodegenerativas no envelhecimento. O objetivo deste estudo foi examinar os perfis de RC em adultos idosos em diferentes estágios da vida, e avaliar o efeito de: (a) gênero e RC; e (b) RC, cognição e sintomas depressivos. A amostra contou com 195 adultos, e uma análise de cluster foi realizada a partir dos escores obtidos na Escala de Reserva Cognitiva. A análise de cluster descreveu dois perfis diferentes. Além disso, as mulheres apresentaram maior RC em comparação aos homens. Os resultados fornecem contribuições importantes para as variáveis relacionadas ao construto da RC.

PALAVRAS-CHAVE: Reserva cognitiva, Envelhecimento, Sintomas depressivos, Cognição, Idosos

The aging process is accompanied by a decline in various cognitive functions, such as memory, attention, information processing, reasoning, language, and the executive functions (Farina et al., 2020; Monica et al., 2018; Tsai et al., 2016). However, the aging process can be significantly different for individuals. Some older adults experience an abrupt cognitive decline, while others maintain a high level of cognitive performance until the end of their life. Although an individual's experience of cognitive aging can be influenced by numerous variables, some individuals seem to be more resilient than others to the debilitating effects of aging (Stern et al., 2019).

Currently, researchers on aging are making considerable efforts to encourage studies into explaining the noticeable heterogeneity in the cognitive functioning of older adults. Some older adults appear to be living to an advanced age without any cognitive or functional impairment, despite brain pathologies (Boyle et al., 2013; Vernaglia, 2019). For Stern et al. (2019), some individuals may have a reserve that allows them to resist the changes caused by the aging process and which mitigates the cognitive damage caused by brain pathologies. The concept of cognitive reserve has been studied and considered as one of the possible variables that can increase an individual's ability to maintain their cognitive performance intact over time and can make cognitive aging more successful (Stern et al., 2019).

The concept of a "reserve" is used to describe the difference between the degree of brain damage observed in an individual and the clinical manifestation of that damage (Stern et al., 2019). According to Stern et al. (2020), the reserve is a hypothetical construct and can be described through two models, the passive and the active. The passive

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model is based on the integrity of the brain structures (Stern et al., 2020), which are responsible for individual differences in the brain's hardware (Stern et al., 2019). On the other hand, the active model is based on an individual remaining active throughout their life, which reduces the effects of age-related cognitive impairment (Stern et al., 2020). The active model focuses on functionality, plasticity and adaptability, which is thought of as the software that performs calculations in the brain and is influenced by all aspects of the individual's experience (Stern, 2009).

The active model of the cognitive reserve is a resource that helps to delay the advance of natural cognitive changes that occur with aging (Stern, 2017). However, there is no consensus about the active model on which components are involved in the cognitive reserve (Stern et al., 2020). Studies suggest that education, work, and an active lifestyle (social interaction, the practice of cognitively stimulating and physical activities) may be related to a higher level of cognitive reserve (Darwish et al., 2018; Evans et al., 2018).

According to a systematic review by Farina et al. (2018), gender, age, education, parental education, occupation, reading activities, social involvement and mood are the main variables in relation to cognitive reserve. Among these, education seems to be one of the main variables. Another empirical study suggested that anxiety has a negative association to cognitive reserve, as well as age. In contrast cognitively stimulating activities, level of education and living with someone were considered factors that helped develop the cognitive reserve of older people (Farina et al., 2021).

Another study suggests that maintaining a socially active lifestyle throughout life can increase the cognitive reserve and has a benefit on cognitive function in older adults (Evans et al., 2018). Wöbbeking-Sánchez et al. (2020) found no differences in the cognitive reserve of older adults when comparing gender (men and women). However, they found differences in the age and education variables: the oldest adults showed more cognitive deterioration, and older adults with a higher level of education demonstrated greater levels of cognitive reserve.

Although cognitive reserve is a promising construct for explaining differences in the cognitive profile of the elderly, we still need to understand how some variables can be related. Therefore, the main objective of this study was to examine the cognitive reserve profiles of older adults at different stages of their life (youth, adulthood, and old age). In addition, we aimed to assess the effect of: a) gender and cognitive reserve and; b) cognitive reserve, cognition and symptoms of depression in older adults.

METHOD

Participants

The sample consisted of 195 older adults recruited on the basis of convenience and because they were community residents. The sample was 118 women and 77 men, who volunteered to take part in the study. With regard to the men's marital status, 76.62% were married, 1.29% separated, 3.89% single and 18.18% widowed. With regard to the women, 53.39% were married, 5.08% separated, 7.62% single and 33.89% widowed. The exclusion criteria were: (a) any suggestion of cognitive decline according to the Mini Mental State Examination (MMSE); (b) any scores that suggested symptoms of depression according to the Geriatric Depression Scale, short version (GDS-15); (c) any defective or uncorrected vision or hearing at the time of assessment; (d) any self-reported neurological diseases (such as a cerebrovascular accident or traumatic brain injury) or coexisting psychiatric disorders (mood or anxiety disorders); and (e) any use of benzodiazepines or antipsychotics. The assessments were conducted individually in a single session of approximately 60 min. The written informed consent of all the participants was obtained and the Research Ethics Committee of the removed by authors, Brazil, approved the development of this study (CAAE removed by authors).

Instruments and Procedures

The general cognitive level was evaluated by the MMSE (Folstein et al., 1975, adapted by Chaves & Izquierdo, 1992). It is a screening instrument to assess cognitive functions (orientation, attention, memory, and language). The score ranges from 0 to 30 points and in this study, we used the cut-off points by education suggested by Kochhann et al. (2010) for older adults from Southern Brazil: < 22 for 5 years of schooling, < 23 for schooling between 6 and 11 years, and < 24 for individuals with 12 years or more of schooling. In this study, the MMSE was used to exclude the older adults with scores suggestive of dementia.

The GDS-15 (Yesavage et al., 1982-1983, adapted by Almeida & Almeida, 1999). was used to identify the presence of depressive symptoms in the older adults. It consists of 15 dichotomous questions ("yes" and "no"), which can be scored 0 or 1, as questions like: "I feel like crying often". This research adopted as cut-off point scores ≥6, which are suggestive of significant symptoms of depression (Paradela et al., 2005).

The Cognitive Reserve Scale (CRS) was originally developed by León-Estrada et al. (2011). The version adapted for Brazilian Portuguese (Landenberger et al., 2021) is a self-reporting scale, consisting of 24 items related to activities, which are intended to be answered in response to

the question "How often did or do I do each of the following activities?", using a Likert scale from 0 to 4 at different times of their lives: youth (18-38 years), adulthood (40-59 years), and old age (≥ 60 years). For example, a young adult (aged 42) would only give an answer for each item for their "youth" and "adulthood", while an older adult (aged 70) would give an answer for all of the items for each stage of life. The Brazilian version had an appropriate degree of internal consistency (α = .94).

Data analysis

The data was analyzed using the SPSS statistical package, version 22, for Windows. Descriptive statistics (mean, standard deviation, and percentage) were used to assess the sociodemographic features. Once assumptions had been checked, a cluster analysis was carried out. This method both continuous and categorical attributes to be used. A TwoStep Cluster analysis was carried out. In the first step, the under the Log-likelihood test based on Schwarz's Bayesian inference criterion (BIC) was calculated for each number of clusters within a specified range, and this was used to arrive at an initial estimate of the number of clusters. In the second step, this initial estimate was refined by finding the largest distance increment between the two closest clusters at each hierarchical clustering stage. In the two-stage clustering procedure used in this study, two distance measures were used. The clustering algorithm was based on one distance measure.

RESULTS

The demographic data is depicted in Table 1, as well as the variables of interest such as GDS-15, MMSE and CRS. It should be noted that no statistically significant differences were found on Age, GDS-15 and MMSE across age under the student t test for independent samples. However, the CRS scores did reach a statistical level of significance. As a result, men were found to score lower than women in youth ($t(193) = -3.04$; $p < .01$; $d' = -0.44$), adulthood ($t(193) = -2.429$; $p < .01$; $d' = -.35$), and old age ($t(193) = -3.25$; $p < .01$; $d' = -.477$). Even though the men ($M = 4.39$, $SD = 3.83$) had studied for slightly less than the women ($M = 5.35$, $SD = 5.10$), there were no statistically significant differences in terms of years in education between the sexes under the Mann-Whitney U test ($p > .05$). Figure 1 shows a boxplot for the whole score on CRS for men and women.

Pearson coefficients were calculated for variables of interest, including GDS-15, to examine and monitor the role of mood. Table 2 depicts these relationships. It should be noted that CRS was only related to cognition in the older adults, while GDS-15 was inversely related to CRS in adulthood and old age.

Lastly, a two-cluster solution was carried out to examine the best model, in terms of the minimized Bayesian inference criterion value (BIC) and the change in this between adjacent numbers of clusters (Table 3). Figure 2 depicts the main predictors for the clusters. It should be noted that the first cluster ($Group_1$) reached a 29.7% of the sample who had lower scores in CRS (colored red in Figure 3), while the second cluster ($Group_2$) consisted of the 70.3% who had better scores (colored blue). In qualitative terms, $Group_1$ could be considered as a group with lower referred scores in cognitive reserve, while $Group_2$ with higher scores in the same variable. This would affect all subfactors of the construct, but not the control variables, MMSE and GDS. More precisely, no differences were found for MMSE and GDS-15 across the clusters (Table 4). A chi-square analysis was carried out across the sex (women versus men) and cluster groups ($Group_1$ versus $Group_2$), which showed statistically significant differences: $\chi 2(1) = 8.50$; $p < .01$.

Table 1
Descriptive Data across the Variables (MMSE, Age, GDS-15, and CRS)

		M	SD	Skewness	Kurtosis	Min	Max
Age	Men	74.94	9.88	.22	-1.22	61.00	97.00
	Women	73.28	9.90	.48	-.43	60.00	102.00
MMSE	Men	26.93	2.00	-.62	-.04	22.00	30.00
	Women	26.39	2.40	-.34	-.92	21.00	30.00
GDS-15	Men	1.98	1.65	.48	-.90	.00	5.00
	Women	2.18	1.47	.22	-.83	.00	5.00
CRS – Youth	Men	38.97	16.36	.06	-1.11	12.00	69.00
	Women	46.05	15.56	-.24	-.04	7.00	91.00
CRS – Adulthood	Men	46.02	12.88	-.02	-.51	19.00	76.00
	Women	50.86	14.04	-.25	.27	15.00	92.00
CRS – Old Age	Men	45.48	12.69	.05	-.40	18.00	77.00
	Women	51.82	13.68	-.32	.73	7.00	92.00

Note. MMSE = Mini Mental State Examination; GDS-15 = Geriatric Depression Scale, short version; CRS = Cognitive Reserve Scale.

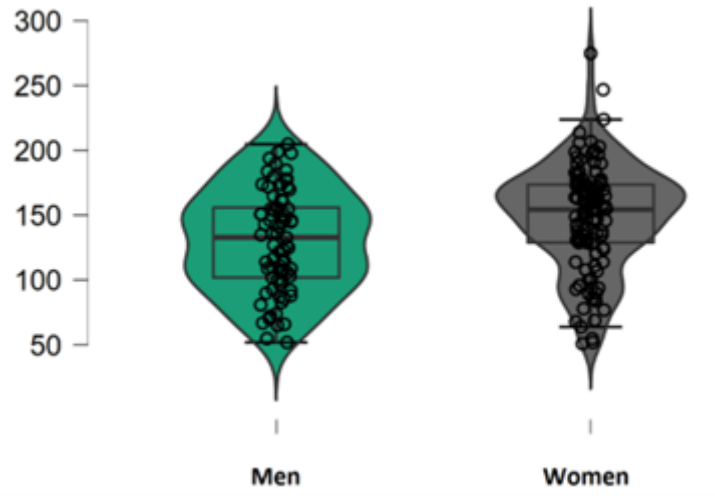

Figure 1. Boxplots on the Cognitive Reserve Scale Total Score across sex

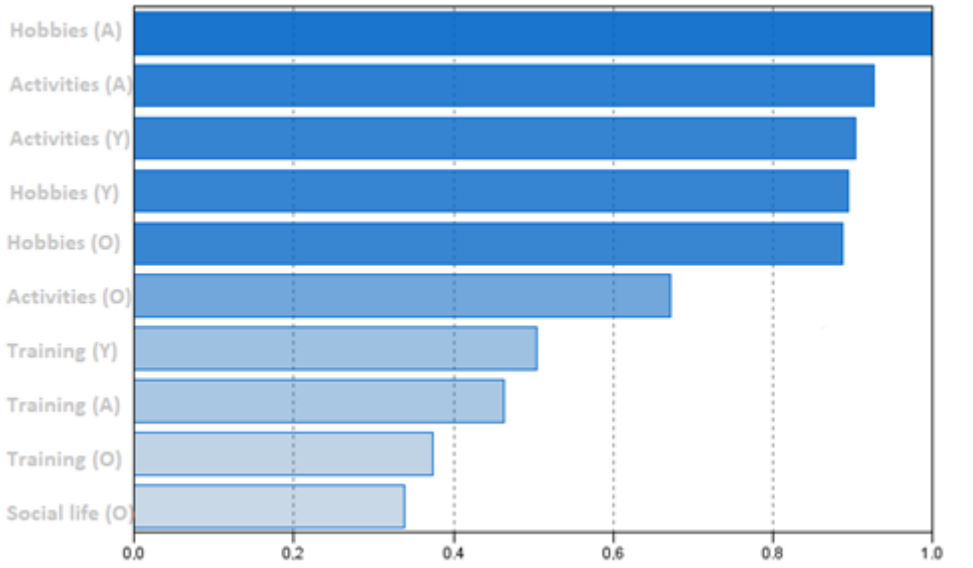

Figure 2. The Importance of the Variables as a Cluster Predictor (from 0 to 1)
Note. A = Adulthood stage on the Cognitive Reserve Scale; Y = Youth stage on the Cognitive Reserve Scale; O = Old Age stage on the Cognitive Reserve Scale.

Table 2
Pearson's Correlations among the Variables

Variables	1	2	3	4	5
1. MMSE	—				
2. GDS-15	-.116	—			
3. CRS – Youth	.034	-.098	—		
4. CRS – Adulthood	.081	-.186**	.866***	—	
5. CRS – Old age	.149*	-.251***	.771***	.882***	—

Note. MMSE = Mini Mental State Examination; GDS-15 = Geriatric Depression Scale, short version; CRS = Cognitive Reserve Scale.
* $p < .05$, ** $p < .01$, *** $p < .001$.

Table 3
Results of Clustering on the basis of Schwarz's Bayesian Inference Criterion (BIC)

Number of Clusters	BIC	BIC change[a]	Ratio of BIC changes[b]	Ratio of distance measures[c]
1	2032.927			
2	1802.733	-230.193	1.000	2.195
3	1778.205	-24.529	.107	1.894
4	1834.924	56.719	-.246	1.044
5	1895.436	60.512	-.263	1.647
6	1990.181	94.745	-.412	1.053
7	2087.611	97.431	-.423	1.190
8	2193.049	105.438	-.458	1.162
9	2304.355	111.306	-.484	1.128
10	2419.782	115.426	-.501	1.175
11	2540.002	120.220	-.522	1.066
12	2661.928	121.926	-.530	1.036
13	2784.739	122.812	-.534	1.024
14	2908.122	123.382	-.536	1.077
15	3033.246	125.124	-.544	1.003

Note. [a] The changes are from the previous number of clusters in the table. [b] The ratios of changes are relative to the change for the two-cluster solution. [c] The ratios of distance measures are based on the current number of clusters against the previous number of clusters

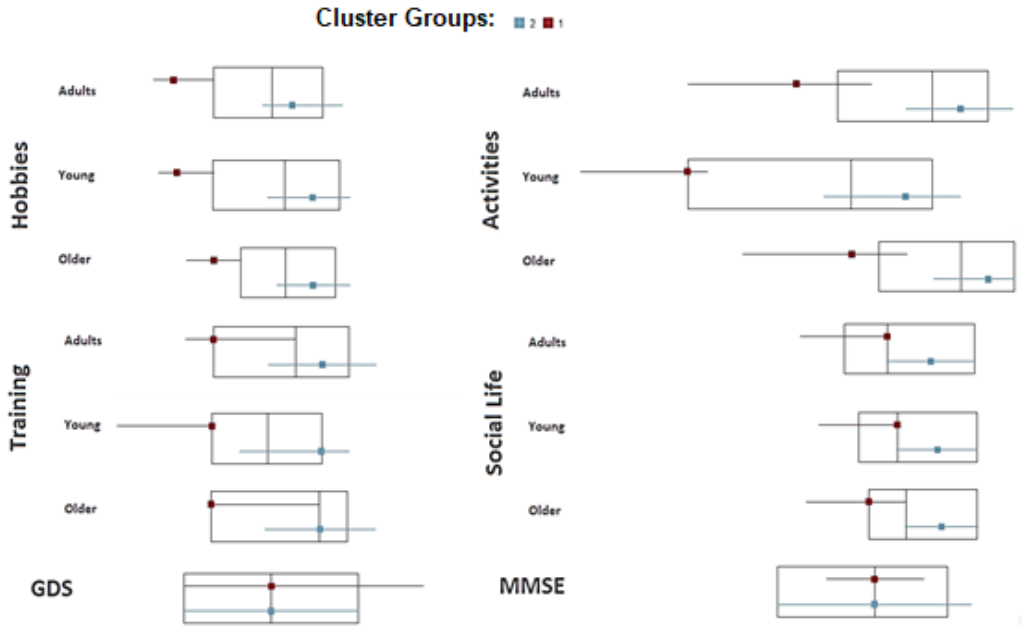

Figure 3. Box and Whisker Plot for each Variable according to the Cluster of Reference ($Group_1$ in red and $Group_2$ in blue).

Table 4
Cross Table across Gender and Clusters

		Sex		Total
		Men	Women	
Cluster	$Group_1$	32	26	58
	$Group_2$	45	92	137
Total	77	118	195	

DISCUSSION

The aim of this paper was to examine profiles on the cognitive reserve of older adults, by taking an analytical approach, such as a cluster analysis. For this reason, a sample of 195 older adults volunteered to participate in this study. Having examined the underlying variables such as GDS-15 and MMSE, a cluster analysis was carried out on their responses related to the CRS, which were divided into three stages of life (youth, adulthood, and old age). The main results can be described as follows: i) the cluster analysis identified two different profiles, one that had low scores for cognitive reserve and a second profile with high cognitive reserve scores; ii) the previous result was consistent for the four subfactors for cognitive reserve, but the Social Life factor was not as markedly different as the rest of the cognitive reserve factors; iii) the pattern scores for each cluster group were consistent across the different stages of life; iv) women have a better cognitive reserve than men and featured more in the second cluster, the group with higher scores in cognitive reserve.

The assumption was that cognitive reserve can be defined as the set of protective physiological, psychological, and environmental factors that can delay or mitigate the cognitive decline associated with ageing (Nilsson & Lövdén, 2018). This study examined the individual's self-perception of their lifetime. In other words, it was based on the participant's perception of how they performed in respect of the different sub-factors for cognitive reserve during their life. According to previous literature, there is evidence linking variables such as affective state and depression, as well as autobiographical memory with the theory on cognitive reserve (Kraemer et al., 2019; Nunnari et al., 2014). In these results, the depression scores were determined by GDS-15, which enabled two different profiles for cognitive reserve to emerge by using this autobiographical perception. One of the groups had lower scores that could be considered alarming to some extent, even if their MMSE or GDS-15 scores were not. It would also be interesting to examine the interaction between mood and self-perception in future research. In particular, the relationship between cognitive reserve and fewer symptoms of depression has been described in previous literature (Murphy, & O'Leary, 2010), which emphasizes the need for intervention in cases of subclinical depression with associated symptoms, e.g., memory issues.

If cognitive reserve is not only related to cognitive functioning but also to the mental health of older people, this reinforces the importance of improving cognitive reserve from early childhood onwards, as mentioned in this study. In relation to the differences between subfactors, the social life variable appeared to be the least affected of the set of cognitive reserve variables. This result suggests that it is not so much the environment and the groups that the elderly are involved in, but rather the activities that they deliberately choose to do in order to remain active. Moreover, this result is not only supported by previous literature (Relander et al., 2021), and the theoretical model regarding active agents (Stern et al., 2020), but it is also consistent in the self-perception of activities, hobbies, and education scores in each stage of life, in this study.

The limitations of this study include a possible bias between men and women. Cognitive reserve scores were not controlled for bias for inclusion in the study, and this is a limitation on generalizing the results based on this variable. The possible differences between the sexes are a hotly debated topic and although it appears that these could mainly be explained by cohort effects, more research is needed in the field on the subject. Although the role of gender as a variable is outside the scope of this paper, it was examined as part of a secondary approach. It was surprising to find that females scored better and were better represented in the cluster with better scores. It has been hypothesized in previous literature that older men have a smaller non-family social network than women, and that the older members of the elderly have a lower cognitive reserve than the younger members (Caetano, Silva, & Vettore, 2013). However, it is likely that the older subgroup is different in terms of education and social opportunities, which leads to an underlying inequality across genders.

In summary, these results are of interest at both an applied and theoretical level. Therefore, one should bear in mind that the theory of the cognitive reserve is one that has aroused the interest of the scientific community because it can provide protection against cognitive decline (Stern et al., 2019). This kind of approach may help to shed light on theoretical models and support training programs. As cognitive reserve is related to the cognitive functioning and mental health of the elderly, programs can be offered that focus on activities and hobbies that can improve cognitive reserve throughout human development.

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