2023, Vol. 23, No. 3
ISSN 1667-4545
Recuperado de https://revistas.unc.edu.ar/index.php/revaluar

Laboratorio de Evaluación Psicológica y Educativa
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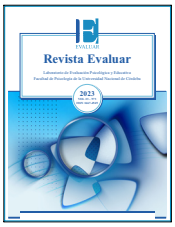

Assessment of Cognitive Flexibility in the Elderly: Evidence for the Validity of the CAMBIOS Test

Evaluación de la Flexibilidad Cognitiva en la vejez: Evidencias de validez del Test CAMBIOS

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Recibido: 21/03/2023 **Revisado:** 12/05/2023 **Aceptado:** 18/05/2023

Abstract

This study aims to accomplish two objectives: (1) To analyze the performance of Cognitive Flexibility (CF) in order to establish normative values in older adults, and (2) to evaluate the external validity evidence of the CAMBIOS Test in the older population from the Rio de la Plata region. An intentional non-probabilistic sample of 200 participants aged 60 to 85 from Mar del Plata divided into two groups was evaluated: younger, on one hand, and middle-aged older adults, on the other hand. Concurrent validity evidence of the CAMBIOS Test with a computerized CF task and criterion-related validity evidence associated with age were presented. Performance differences in CF were observed based on age. The scores in the age-associated CF level were equivalent between both instruments. The CAMBIOS Test proved to be useful for assessing CF, enabling the development of normative values for the regional older adult population, discriminated by age subgroups in the aging process.

Keywords: *CAMBIOS Test, cognitive flexibility, older adults, validity*

Resumen

Este estudio propone dos objetivos: (1) analizar el desempeño de la Flexibilidad Cognitiva (FC) y establecer valores normativos en las personas mayores y (2) evaluar las evidencias de validez externa del Test CAMBIOS en la población rioplatense de personas mayores. Se evaluó una muestra no probabilística intencional de 200 participantes de 60 a 85 años de edad de Mar del Plata, distribuidos en dos grupos: mayores jóvenes y mayores intermedios. Se presentan evidencias de validez concurrente del Test CAMBIOS con una tarea informatizada de FC y evidencias de validez de criterio asociado a la edad. Según la edad, se evidenciaron diferencias en el desempeño en FC. Las puntuaciones en el nivel de FC, asociado a la edad, resultaron equivalentes entre ambos instrumentos. El Test CAMBIOS resultó útil para evaluar la FC, posibilitando la elaboración de valores normativos para la población regional de personas mayores, discriminado por subgrupos de edad en el envejecimiento.

Palabras clave: *test CAMBIOS, flexibilidad cognitiva, personas mayores, evidencias de validez*

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How to cite: Krzemien. D., Barrio. D., Ferreyra. F., & Richard´s. M. (2023): Assessment of Cognitive Flexibility in the Elderly: Evidence for the Validity of the CAMBIOS Test. *Revista Evaluar, 23*(3), 1-15. Retrieved from https://revistas.unc.edu.ar/index.php/revaluar
Participaron en la edición de este artículo: Abigail Pérez, Andrea Suárez, Juan Cruz Balverdi Nieto, Florencia Ruiz, Benjamín Casanova, Jorge Bruera.

Introduction

Cognitive Flexibility (CF) is a component of executive function located in the prefrontal cortex (Uddin, 2021). CF is the ability to simultaneously switch between modes of thinking about multiple aspects of a complex object or situation (Diamond, 2013). It refers to the ability to process one set of stimuli and alternate with the simultaneous processing of another set (Seisdedos, 2008). It also involves recognizing the intermittent change of rules or criteria in a task, having an appropriate tolerance for it, and not persisting with the previous criterion. As tasks demand change, the cognitive system can adapt itself by shifting the attention and selecting the specific information to provide a response and in so generating new activation states to provide feedback to the system. When these processes result in representations and actions that adapt to task changes, a person's behavior can be considered flexible (García-Coni & Vivas, 2014; Ionescu, 2017).

In the current context, maintaining or improving cognitive functions in older adults and reducing the prevalence of neurodegenerative diseases have become the focus of health care and research (Burke et al., 2019; Krzemien, 2013; Siagian et al., 2020; Mather, 2020). Given the role that executive functions play in maintaining independence and a good quality of life, they are considered a prerequisite for optimizing healthy aging (Betancourt-Zambrano et al., 2020; Lepe-Martínez et al., 2020; Stieger & Lachman, 2021). CF has been found to predict performance in daily life instrumental activities (Bell-McGinty et al., 2002; Vaughan & Giovanello, 2010).

Neuropsychological studies (Dorbath et al., 2013; Ferguson et al., 2021) have shown that executive functions are affected by aging. There is evidence that aging is associated with a decline in the efficiency of certain cognitive processes, such as cognitive flexibility, episodic memory, visuospatial functions and attention, among others, which are related to brain circuitry changes (Reuter-Lorenz & Park, 2014). However, other studies in older adults with pathologies, such as type 2 diabetes mellitus and hypertension found that the components of executive function, which were affected the most by aging, were working memory and planning, while mental flexibility and verbal fluency were more preserved (Aguilar-Mateu et al., 2014).

The developmental trajectory of CF has been found to show a progressive decline from adulthood to old age (Krzemien et al., 2018a; Richard's et al., 2023). Some authors report perseverative responses, an increase in the number of errors, and a decrease in the number of complete responses in older adults compared to young individuals (Herrera & Eizaguirre, 2020; Romo-Galindo et al., 2015; Roselli et al., 2008; Wecker et al., 2005). Among the proposed explanations, it has been suggested that older adults have difficulty generating new hypotheses about constantly changing rules (Rosselli et al., 2008).

On the other hand, several studies assert that neurocognitive changes associated with aging do not inevitably imply a cognitive decline in all performance domains, nor do they follow the same direction and sequence of slowing or deterioration (Baltes et al., 2007; Grandi & Tirapu-Ustárroz, 2017). Instead, a variety of changes in neurocerebral activity takes place which are specific to normal aging. There is empirical evidence of brain plasticity and neuronal activation in old age (Clare et al., 2017; Hakun et al., 2015) which challenges the notion of frontal lobe vulnerability and the common assertion that processes mediated by this lobe deteriorate with age.

There are studies (Martins et al., 2015; Meunier et al., 2014; Ojeda et al., 2019) that explain preserved cognitive function in the context

of neuroanatomical and functional changes due to aging based on compensatory mechanisms as one of the main factors influencing cognitive performance. During aging, a greater number of brain areas are activated to support the control of a specific function at a given time (Wang et al., 2010). However, there is a cost in terms of reduced efficiency when multiple brain areas are activated in a generalized manner, making a more specialized system more efficient than a diffuse one (Van den Heuvel et al., 2009).

The method typically used to assess executive functions has generally been performance measures (Morales-Millán et al., 2021). A methodological issue that requires attention in the field of gerontological cognitive assessment is the validity of executive function performance tests of executive functions. Some of the instruments traditionally used to measure CF use a global index that assesses executive functions as a whole (e.g., Wisconsin Card Sorting Test, Trail Making Test, Rings Test), which hinders the evaluation, while the interpretation makes it difficult to assess and interpret each function independently (Miyake et al., 2000; Uddin, 2021). In particular, the CAMBIOS test allows the specific measurement of CF, since it can assess the alternation between different rules that the person must consider simultaneously and recognize when they change with increasing complexity.

On the other hand, the adaptation and development of regional normative values for executive function assessment techniques in older adults remain an open task. It is crucial to obtain standardization norms that are adapted to the characteristics of the specific population under study (Tornimbeni et al., 2004). The use of existing norms originally derived from other regions, cultures, or age groups is not recommended when studying the older adult population from a different regional context (Rosselli & Ardila, 2003). This is especially important given the heterogeneity of cognitive performance within the aging process, where there are interindividual differences and characteristics based on age subgroups. Old age cannot be viewed as a homogeneous group with general patterns. Furthermore, given the cohort differences, it is advisable to have normative data specific to the age subgroups of older adults in the local context.

This study aims to analyze CF performance in old age and to provide evidence for the metric adaptation of the CAMBIOS test in the Rioplatense population of younger and middle-aged older adults.

To achieve this, evidence of the external validity (concurrent) of the CAMBIOS test is presented based on correlations with a computerized CF task, as well as evidence of age-related validity based on scores obtained on both instruments in older adults. This study proposes two specific objectives: first, to analyze CF performance based on educational level and gender and to develop preliminary normative values in a sample of Rioplatense older adults; and second, to obtain evidence of concurrent and age-related validity of the CAMBIOS test in a subsample of older adults.

Methods

Design and participants

A correlational, nonexperimental and cross-sectional study was conducted (Montero & León, 2007). The total sample was selected using non-probability purposive sampling and consisted of 200 participants. Hypothesis testing sampling was also used (Padua, 1982), resulting in 100 women and 100 men. Within each gender group, two subgroups based on age were considered: Group 1 included younger older adults (60 to 69 years) and Group 2 included middle-aged

Table 1
Descriptive characteristics of the Study One sample discriminated by age groups (n = 200).

		Group 1 (60 to 69 years old)		Group 2 (70 to 85 years old)	
Age - M (SD)		64,06 (3,01)		74,26 (3,65)	
		Frequency	%	Frequency	%
Gender	Male	64	51	36	48,6
	Female	62	49	38	51,4
Educational level	Primary	14	11	12	16,2
	Secondary	47	37	28	37,8
	Tertiary / University	65	52	34	45,9
Retirement	Retired	82	65	71	95,9
	Not Retired	44	35	3	4,1
Occupation	Housewife	7	5,6	5	6,8
	Administrative employee	30	24	18	24,3
	Professional	37	29	20	27
	Technician / manager / trades	17	14	11	14,9
	Teacher	13	10	10	13,5
	Businessman	22	18	9	12,2
Coexistence	Only	25	20	31	41,9
	With family member	101	80	43	58,1
Subtotal		126			74

Note. Group 1 (group of young older people). Group 2 (group of middle-aged older adults).

older adults (70 to 85 years). Participants with at least complete primary education were included, while those residing in long-term care facilities and those with cognitive disorders were excluded. To rule out the presence of cognitive deficits, the ACE-III (Bruno et al., 2020) was used as a screening test, with an established cut-off point of 86 for individuals with basic education and a maximum score of 100. Group 1 had a mean score of 89.03 (2.90), and Group 2 had a mean score of 87.78 (3.51). The sample was drawn from various community institutions, including UPAMI (University for Integrated Older Adults) extension courses, the University Program for Lifelong Learning, senior centers, day clubs, the Municipal Gerontological Unit, and individuals without institutional affiliation who were interviewed in their homes.

Based on the overall objectives, two studies were conducted, which are presented below:

Study 1: Analysis of the performance of CF in old age. Development of normative values in Rioplatense older adults. This study included a total sample of 200 participants with the characteristics described in the Methods section. The CAMBIOS test was administered to all participants, taking into account the gender and age group criteria (Table 1).

Table 2
Descriptive statistics of socio-occupational and educational variables for the subsample of Study 2, discriminated by age groups (n = 50).

		Group 1 (60 to 69 years old)		Group 2 (70 to 85 years old)	
Age - M (SD)		64,06 (3,01)		74,26 (3,65)	
		Frequency	%	Frequency	%
Gender	Male	64	51	36	48,6
	Female	62	49	38	51,4
Educational level	Primary	14	11	12	16,2
	Secondary	47	37	28	37,8
	Tertiary / University	65	52	34	45,9
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	Teacher	13	10	10	13,5
	Businessman	22	18	9	12,2
Coexistence	Only	25	20	31	41,9
	With family member	101	80	43	58,1
Subtotal		126			74

Note. Group 1 (group of young older people). Group 2 (group of middle-aged older adults).

Study 2: Evidence of the validity of the CAMBIOS test of cognitive flexibility. In order to obtain evidence of concurrent validity, a purposive sub-sample of 50 individuals (25 females) was purposefully selected from the total sample, while maintaining the same socio-occupational characteristics. These individuals were assessed using the CAMBIOS test and also completed the Fingers Task from the Cognitive Self-Regulation Battery (TAC), a computerized task. Age was also taken into account for these 50 individuals, using the same criteria as for the general sample: Group 1 consisted of younger older adults (60 to 69 years) and Group 2 consisted of middle-aged older adults (70 to 85 years) (see distribution in Table 2).

Instruments

Socio-Educational Data Questionnaire. This is a short instrument with easy administration, developed ad hoc and consisting of closed-ended questions about participants' socio-occupational data and educational level. This questionnaire has been used in several studies conducted in our context and with samples of older adults (Krzemien, et al., 2018a). Estimated time of administration: five minutes.

Addenbrooke's Cognitive Examination-III (ACE-III, Argentine adaptation by Bruno et al., 2020). This brief test detects dementia and assesses five cognitive domains: attention, memory, verbal fluency, language and visuospatial abili-

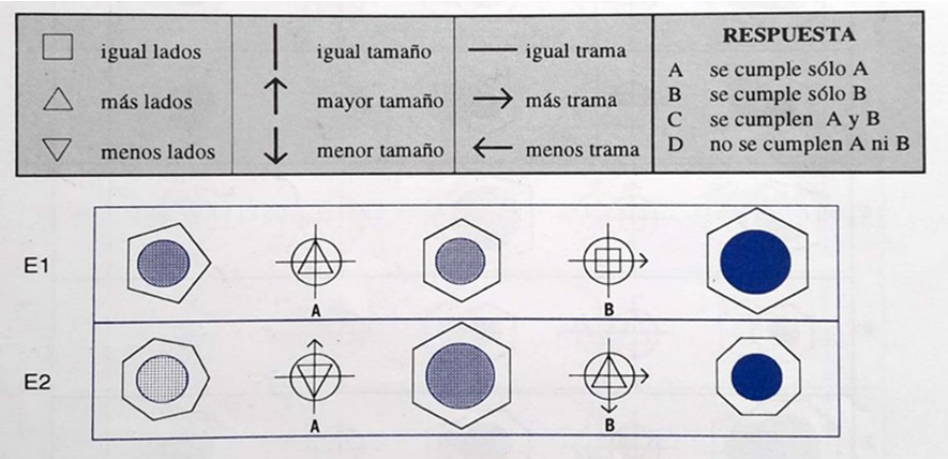

Figure 1
Description of the CAMBIOS Test command.
Source: Seisdedos, N. Cognitive Flexibility Test (CAMBIOS). TORCH. 2008 (Image taken from the original CAMBIOS test protocol, pages 11-13 of the manual).

ties. Individuals with basic education must score above the cutoff of 86, with a maximum score of 100. The Argentine version of the ACE-III has good internal consistency (Cronbach's alpha = .87), and significant differences in total ACE-III scores were found between the control and dementia groups ($p < .05$). Estimated time of administration: 20 minutes.

CAMBIOS Cognitive Flexibility Test (Seisdedos, 2008). It is a visual test free of verbal influence that assesses the use of a flexible and efficient action strategy when faced with simple tasks. It is designed to measure the logical processes necessary to comply with change conditions. This test measures organized and systematic behavior that responds quickly to classification stimuli. It assesses the ability to concentrate while attending to various changing conditions in the stimulus and the flexibility to analyze whether or not different requested changes are fulfilled and when they have ceased to be fulfilled. The test consists of 27 elements that contain simple geometric figures (polygons from five to nine sides with an interior color pattern), on which three simple types of changes can be requested: the increase or decrease of one or several of its characteristics, that is, the number of sides of the polygon, the size of the figure and the intensity of the pattern. The types of errors that the examinee could commit are perseverance or redundancy in the answer, omission, and non-recognition of the type of rule that is requested. The final score is only analyzed from the hits achieved within the predetermined time limit. In its original Spanish version, the test has adequate psychometric properties (the reliability coefficient for the two-half method obtained a correlation of .92). It has a minimum average execution time of seven minutes for the Spanish youth population. In previous studies in groups of older people (Krzemien, et al., 2018b), the execution time of the complete test (from one to 27 exercises) was 25 minutes, therefore, a maximum time limit of 14 minutes was determined for older people from the Rio de la Plata context. This limit as a cut-off point makes it possible to evaluate the examinee's performance (in terms of the number of correctly completed exercises as hits) in a time appropriate to the age group of older people (twice as many minutes as in the original version for young people) and thus to evaluate the CF in terms of speed of response (Figure 1).

For the test as a whole, the averages have a

Figure 2
Examples of the three blocks of the Finger Task: (a) Congruent trials, (b) Incongruent trials, and (c) Mixed trials.
Source: In Introzzi, I., Richard´s, M., & Canet-Juric, L. (2019). TAC: Tareas de Autorregulación Cognitiva (www.tac.com.ar). Revista Argentina de Neuropsicología.

difficulty index of .57, a correlation index of .18, and a homogeneity index of .42. These results define the medium difficulty and good internal consistency of the test in a sample of Spanish young adults (Seisdedos., 2008). In our country, in a recent study (Vido et al., 2018), the test was applied to a sample of older people, obtaining reference values for this age group.

Finger Task from the Computerized Battery TAC (Introzzi & Canet-Juric, 2019). This is a modified version of the original task by Davidson et al. (2006) and adapted by Richard's et al. (2019) for older adults. The task consists of three rating blocks: Congruent, Incongruent and Mixed. Each rating block is preceded by a practice block of eight trials. A hand with an index finger (stimulus) appears on the screen indicating the direction in which the participant should press the key (right or left). The interval between stimuli is 1500 milliseconds, and each stimulus remains on the screen for 3000 milliseconds, during which the participant must respond. The (1) Congruent block contains 20 trials (ten stimuli presented on the left and ten on the right, randomly on the screen). The participant must press the key on the same side as the stimulus (ipsilateral response). The (2) Incongruent block consists of 20 trials (ten stimuli presented on the right side of the screen and ten on the left side). The participant must press the key on the opposite side of the stimulus (contralateral response). The (3) Mixed block consists of all stimuli from the previous blocks which appear randomly (20 congruent and 20 incongruent trials). This block specifically measures cognitive flexibility as the participant must quickly and efficiently switch between two incongruent rules (ipsilateral or contralateral response). The performance indices obtained in the three blocks are the average percentage of correct responses (accuracy) and the average response times. Some authors suggest using a measure that combines speed and accuracy (Klein et al., 2004). For this purpose, the Inverse Efficiency (IE) index was used, which is the ratio of RT to accuracy, i.e. the value of RT divided by one - PE (proportion of errors). Since RT is expressed in milliseconds and divided by proportion (% correct), the index is also expressed in milliseconds. The time to complete the task is 15 minutes (Figure 2).

Procedure and data analysis

The techniques were administered to the participants under standardized conditions in a single session lasting 50/55 minutes, with a ten-minute break. First, they were informed about the purpose and importance of the study, and the voluntary nature and confidentiality of the data were guaranteed by current regulations (guidelines recommended by the American Psychological Association, National Law on the Protection of Personal Rights No. 25,326, Inter-American Convention on the Protection of Human Rights of the Elderly of the Organization of American States 2015, and guidelines for Social Sciences and Humanities of the Ethics Committee - CONICET 2857-06).

Descriptive and inferential statistical tests were used to analyze performance in CF (Cognitive Flexibility) in both assessment instruments (CAMBIOS and Finger Task). To obtain evidence of validity, two studies were performed: a) analysis of the evidence of external validity (concurrent validity) of the CAMBIOS test, based on correlations with the Cognitive Flexibility Finger Task of the computerized battery, and b) analysis of the evidence of age-related validity (lower performance with increasing age), considering the scores obtained in both instruments in younger and middle-aged older adults. To compare performance differences based on age, two groups were considered according to the criteria established in previous studies on cognitive development in old age (Salthouse, 2018): Group 1, younger older adults aged 60 to 69, and Group 2, middle-aged older adults aged 70 to 85. The data analysis plan was carried out in several steps. First, descriptive analyses of the study variables were conducted by age group. Second, a means test was administered to determine performance differences based on gender, and an analysis of variance (ANOVA) was conducted to investigate whether performance in CF varied according to educational level. Third, correlation coefficients were calculated between the CAMBIOS test scores and the finger task scores to analyze the criteria of external validity (concurrent validity). Fourth, to determine compliance with age-related validity criteria, a mean difference analysis or T-test was applied based on the groups of younger and middle-aged older adults.

Results

Study 1: Analysis of CF performance during old age based on educational level and gender, and development of normative values in elderly from the Rio de la Plata region.

According to the scores obtained in both instruments (CAMBIOS and Finger Task), the performance of the middle-aged older adults group [M = 11.12 (5.74)] is lower than that of the younger older adults group [M = 15.52 (5.50)]. Considering the data from a previous local study conducted in 2019 in the city of Mar del Plata, the mean score achieved in the CAMBIOS test by the middle-aged older adults group was 9.13 (4.70), while the mean score for the younger older adults was 14.86 (6.30). This indicates that the higher performance of the younger age group is consistent across both studies (2019 and 2022) (Table 3).

An ANOVA was conducted to determine if performance in CF varied by educational level (primary, secondary, and university), but no significant differences were found ($p > .01$). Furthermore, a means test was conducted to determine if there were differences in performance based on gender, and the results indicated that there were no significant differences ($p > .01$).

Table 3
Statistical values of central tendency and variability of CF performance on the CAMBIOS test, discriminated by age groups, in two studies. (Years 2019 and 2022).

	Estudio actual (N= 200) Año 2022		Estudio previo (N = 51) Año 2019	
	Group 1	**Group 2**	**Group 1**	**Group 2**
N	126 (64)	74 (36 males)	28 (14 males)	23 (15 males)
Age	64,06 (3,01)	74,26 (3,65)	64,24 (3,39)	75,57 (3,92)
CAMBIOS Test	15,52 (5,50)	11,12 (5,74)	14,86 (6,30)	9,13 (4,70)

Note. Group 1: Younger older adults. Group 2: Middle-aged older adults.

Table 4
Percentile values for each level of performance in CF for the total sample (n = 200).

N		**200**
Mean (SD)		13,9 (5,97)
Minimum/Maximum:		2 / 27
Percentiles	10	6-7
	20	8
	25	9
	30	10-11
	40	12-13
	50	14
	60	15-16
	70	17
	75	18
	80	19-22

Table 5
Percentile values for each level of performance in CF, according to age groups.

PP	**Group 1 (N= 126)**	**Group 2 (N= 74)**
10	8-10	4-5
20	11	6
25	12	7
30	13	8
40	14	9
50	15-16	10-11
60	17	12-13
70	18-19	14
75	20	15
80	21-23	16-19
90		

Note. Group 1: Younger older adults. Group 2: Middle-aged older adults.

First, to obtain the normative values of the CAMBIOS test in older Rioplatense adults, the performance of the total sample (N = 200) is described, differentiated by quartiles (25, 50, 75 and 100). In this way, the CF performance of individuals is known across levels from low (quartile 1, 0 to 25) to high (quartile 4, 75 to 100). In addition, percentile values of performance level were obtained for the entire sample (Table 4). Second, percentile values of CF performance level differentiated by age groups were obtained (Table 5).

Study 2: Validity Evidence of the CAMBIOS Test for Cognitive Flexibility.

This study aims to provide evidence of the concurrent and age-related validity of the CAMBIOS test in a sub-sample of Rioplatense older adults.

2.1 External (concurrent) validity evidence of the CAMBIOS Test based on correlations with the Finger Task of the TAC computerized battery.

The Pearson correlation coefficient was applied between the following indices: number of

Table 6
Values of Centrality and Variability of cognitive flexibility performance in the Finger Task of the TAC in the sample of Study 2, discriminated by age group.

	Study 2 (N= 50)	
	Group 1	**Group 2**
N	32 (17 males)	18 (8 males)
Age - M (SD)	63,72 (2,59)	74,78 (3,42)
Finger Task		
RT (ms) - M (SD)	853,69 (112,24)	961,61 (241,18)
Accuracy (%) - M (SD)	96,31 (9,81)	87,94 (16,85)
IE- M (SD)	9,09 (2,53)	11,58 (4,42)

Note. Group 1: Younger older adults. Group 2: Middle-aged older adults. IE: Inverse Efficience Index (IE): RT/Accuracy. The higher IE index value, the worse performance of CF.

correct responses in the CAMBIOS test, number of correct responses, average response times, and the Inverse Efficiency Index of the Finger Task in the TAC, within a subsample of 50 individuals. In all cases, statistically significant correlations were observed, albeit moderate in strength. Specifically, a) a negative correlation (r = -.37; p < .01) was found between correct responses on the CAMBIOS test and response times on the Finger Task, while b) a positive correlation (r = .41; p < .01) was found between correct responses on the CAMBIOS test and correct responses on the Finger Task. Finally, c) a negative correlation (r = -.45; p < .01) was found between correct responses on the CAMBIOS test and the Inverse Efficiency Index of the Finger Task. Thus, individuals who achieved a higher number of correct responses on the CAMBIOS test tended to have a lower Inverse Efficiency Index on the Finger Task, indicating better cognitive flexibility performance. Consistent with theoretical expectations, statistically significant correlations were found between the CAMBIOS test scores and the main performance indices of cognitive flexibility in the Finger Task. This suggests that both tests measure cognitive flexibility in the same direction, in a way that individuals who demonstrate high levels of cognitive flexibility on the CAMBIOS also demonstrate high levels of cognitive flexibility on the TAC Finger Task. These findings provide empirical support for concurrent validity.

Regarding the intergroup analysis of cognitive flexibility performance on the finger task, the younger older adults group showed higher performance (shorter response times and higher number of correct responses) compared to the middle-aged older adults group. The average Inverse Efficiency Index for the group of younger older adults was 9.09 (2.53), while for the group of middle-aged older adults was 11.58 (4.42). It can be observed that the younger older adults were more efficient in their responses with shorter response times compared to the middle-aged older adults. In summary, the level of cognitive flexibility performance is higher in younger older adults than in middle-aged older adults, with an increase in response times and number of errors in the older age group (Table 6).

2.2. Evidence of age-related validity of the CAMBIOS Test in older Rioplatense subjects

To determine differences in CF performance on the CAMBIOS Test between the two age groups, an independent sample T-test was performed, which revealed statistically significant differences (t = 5.37; df = 198; p < .01). Similarly, in the performance on the Finger Task, statistical-

ly significant differences were found in all three indices: accuracy (t = -2.22; df = 48; p < .01), response times (t = -2.16; df = 48; p < .01), and inverse efficiency index (t = -2.53; df = 48; p < .01), with the younger elderly group achieving higher performance. Therefore, it is evident that the performance in CF is higher in younger elderly compared to middle-aged elderly.

Discussion

The present study has shown that the CAMBIOS test and the finger task of the computerized TAC battery are useful for assessing the level of cognitive flexibility in the elderly Rioplatense population, specifically and relatively independent of other executive functions. Older individuals who performed well on the TAC computerized task also performed better on the CAMBIOS test. Conversely, those older individuals who showed low levels of cognitive flexibility on the CAMBIOS also showed poorer performance on the computerized task. In conclusion, these results provide evidence of the external validity of the adaptation of the CAMBIOS Test in the Rioplatense population of elderly individuals and contribute to regional normative values for this instrument. Thus, the CAMBIOS test appears to be a valid tool for assessing cognitive flexibility in elderly individuals without neurocognitive pathology.

When comparing the results obtained from both age groups, statistically significant differences were found in all three indices assessed in the finger task (accuracy, response time, and inverse efficiency index). This is consistent with findings from recent years (Introzzi et al., 2020; Richard's et al., 2023; Richard's et al., 2019), where older adults are not considered a homogeneous group. Within this life stage, distinct subgroups with different characteristics emerge. In the case of the CAMBIOS test, statistically significant age-related differences were also observed. Younger older adults outperformed middle-aged adults, as expected given the specific age-related changes in brain activity during executive cognitive control (Spreng et al., 2017).

However, current research cautions that there are no uniform changes in all cognitive domains and functions with advancing age. Environmental factors, experience, and lifestyle can lead to significant differences in cognitive performance in old age (Barulli & Stern, 2013; Bartrés-Faz et al., 2018; Krzemien, 2016; Krzemien et al., 2018b; Oosterhuis et al., 2023). Given the interest in studying interindividual differences in cognitive aging trajectories that modulate the efficacy of executive functions, neurocognitive assessment techniques that allow the discrimination of specific performance indices related to each cognitive domain or function and that are sensitive to dynamic changes during aging are needed. In this regard, the CAMBIOS test makes it possible to obtain performance indices of cognitive flexibility that discriminate between age groups (young older adults and middle older adults) within the older age range. It would be of interest in future studies to compare performance in samples from other stages of the life span, such as young adulthood, middle adulthood, and late adulthood.

Both the Finger Task and the CAMBIOS test specifically assess cognitive flexibility, with increasing levels of complexity as the task progresses from simple to more complex stimulus presentation. The Finger Task provides specific indices of processing speed, while the CAMBIOS test considers responses given within a maximum time limit for older adults.

On the other hand, this study did not find statistically significant differences in CF performance related to gender and educational level

among older adults. Similarly, in the normative study of the Trail Making Test in the Buenos Aires population, no differences in educational level were found in the group of individuals aged 65 years and older (Margulis et al., 2018). Therefore, formal education does not seem to affect neuropsychological functioning in terms of CF in this sample. This could be because this process is more closely related to neurobiological and neurocognitive aspects and less influenced by educational learning and gender connotations.

The normative data provided in this study can be considered useful for the appropriate interpretation of the accuracy within a specific performance time for older adults in the Rioplatense region. The use of this CAMBIOS test can provide diagnostic guidance in gerontological professional practice. These results will contribute to the design of interventions and cognitive training programs aimed at optimizing cognitive flexibility, promoting the improvement of executive function and preventing the risk of neurodegenerative pathology in old age. It is recommended that future studies expand the sample to include diverse cultural contexts and further develop the adaptation of the CAMBIOS instrument as a gerontological cognitive assessment tool, which will contribute to increase the knowledge about this executive function in old age.

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