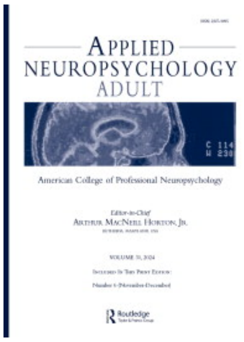

Routledge
Taylor & Francis Group

Applied Neuropsychology: Adult

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/hapn21

Inventory of sensory, emotional, and cognitive reserve (SECri): Proposal of a new instrument and preliminary data

Joana O. Pinto, Isabel Vieira, Beatriz C. R. Barroso, Miguel Peixoto, Diogo Pontes, Bruno Peixoto, Artemisa R. Dores & Fernando Barbosa

To cite this article: Joana O. Pinto, Isabel Vieira, Beatriz C. R. Barroso, Miguel Peixoto, Diogo Pontes, Bruno Peixoto, Artemisa R. Dores & Fernando Barbosa (27 Sep 2024): Inventory of sensory, emotional, and cognitive reserve (SECri): Proposal of a new instrument and preliminary data, Applied Neuropsychology: Adult, DOI: 10.1080/23279095.2024.2407462

To link to this article: https://doi.org/10.1080/23279095.2024.2407462

View supplementary material

Published online: 27 Sep 2024.

Submit your article to this journal

View related articles

View Crossmark data

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=hapn21

APPLIED NEUROPSYCHOLOGY: ADULT
https://doi.org/10.1080/23279095.2024.2407462

Routledge
Taylor & Francis Group

Check for updates

Inventory of sensory, emotional, and cognitive reserve (SECri): Proposal of a new instrument and preliminary data

Joana O. Pinto[a,b,c,d], Isabel Vieira[a], Beatriz C. R. Barroso[b], Miguel Peixoto[b,c,d], Diogo Pontes[b], Bruno Peixoto[a,f,g], Artemisa R. Dores[c,d,b] and Fernando Barbosa[b]

[a]CESPU, University Institute of Health Sciences, Gandra, Portugal; [b]Laboratory of Neuropsychophysiology, Faculty of Psychology and Education Sciences, University of Porto, Porto, Portugal; [c]ESS, Polytechnic of Porto, Porto, Portugal; [d]Center for Rehabilitation Research, ESS, Polytechnic of Porto, Porto, Portugal; [e]Lusófona University, Porto, Portugal; [f]NeuroGen - Center for Health Technology and Services Research (CINTESIS), Porto, Portugal; [g]TOXRUN – Toxicology Research Unit, University Institute of Health Sciences, CESPU, Gandra, Portugal

ABSTRACT

A new model of reserve, the Sensory, Emotional, and Cognitive Reserve (SEC) model, has been recently proposed, but so far this model has not been operationalized in instruments to evaluate the different domains of the reserve. This study introduces the SEC reserve inventory (SECri) along with preliminary data obtained from a study involving 57 adults, aged 35 and older. The SECri assesses the SEC domains using specific proxies: (a) sensory reserve (SR) through sensory acuity and sensory perception proxies; (b) emotional reserve (ER) through life events, resilience, and emotional regulation proxies; and (c) cognitive reserve (CR) through education, occupation, socioeconomic status, bilingualism, leisure activities, and personality traits proxies. Key features of SECri include self- and informant-report forms, fine-grained response scales, and the evaluation of reserve development across the lifespan. Findings on the acceptability, convergent validity between SECri domains and validated tests for the same constructs, internal consistency of each domain, and predictive validity of Montreal Cognitive Assessment scores support further research with this inventory. Future studies should consider determining SECri's psychometric properties in clinical and subclinical conditions to evaluate its prognostic value in cases of neurocognitive decline.

KEYWORDS
Cognitive reserve; emotional reserve; SEC model; sensory reserve

Introduction

The existence of cognitive reserve (CR) is a hypothesis that describes the adaptability of cognitive processes, emphasizing their efficiency, capacity, and flexibility, which helps explain the varying susceptibility of cognitive abilities or functionality to brain alterations (Stern et al., 2020). The interest in CR aroused in the field of pathological aging and spread to different neurological disorders, as well as for healthy aging (León et al., 2014). Despite remaining a hypothesis, CR is attracting considerable interest, and it is consistently reported as essential for understanding the disparity between the severity of brain aging, pathology or injury, and clinical symptoms of cognitive dysfunction (Stern, 2009). Considering that CR involves the accumulation of cognitive resources during the lifespan, it is dynamic and influenced by exposure to different proxies across life (Cabeza et al., 2018; Stern et al., 2020). Therefore, CR can operate along with maintenance (i.e., preservation of cognitive resources) and compensation processes (i.e., allocation of reserve resources to face task demands) (Cabeza et al., 2018).

Given that CR is a theoretical construct, it cannot be directly evaluated, leading to the complexity of its operationalization (Harrison et al., 2015; Pinto et al., 2024). Several proxies have been proposed for CR estimation, with education being the most commonly considered (Pinto et al., 2024; Stern et al., 2020). Among the most used instruments to operationalize CR are the Cognitive Reserve Index Questionnaire (Nucci et al., 2012), the Cognitive Reserve Questionnaire (Rami et al., 2011), and the Cognitive Reserve Scale (León et al., 2011; Pinto et al., 2024). To the best of our knowledge, the Cognitive Reserve Index Questionnaire (Nucci et al., 2012) is translated into many languages, but not validated for all countries. The Cognitive Reserve Questionnaire (Rami et al., 2011), focused on individual education, parents' education, leisure time, and bilingualism, showed acceptable internal consistency in a sample of participants with probable Major Neurocognitive Disorder due to Alzheimer's Disease (Cronbach's alpha = .80) (León et al., 2011; Sobral et al., 2014). The Cognitive Reserve Scale focused on daily activities, training information, hobbies, and social life and showed an internal consistency as high as .93 in a sample of healthy older adults (e.g., see Tomás, 2020).

Recently, it was proposed an updating to the CR model to include two other individual types of reserve, the sensory

CONTACT Joana O. Pinto joana.pinto@iucs.cespu.pt CESPU, University Institute of Health Sciences; Laboratory of Neuropsychophysiology, Faculty of Psychology and Education Sciences, University of Porto, Porto, Portugal; E2S, Polytechnic of Porto, Porto, Portugal; Center for Rehabilitation Research, E2S, Polytechnic of Porto, Porto, Portugal.
Supplemental data for this article can be accessed online at https://doi.org/10.1080/23279095.2024.2407462.
© 2024 Taylor & Francis Group, LLC

reserve (SR) and the emotional reserve (ER), leading to the Sensory, Emotional, and Cognitive reserve model (SEC model). SR concerns the adaptability of sensory processes, explaining individual differences in processing sensory information in cases of sensory-related diseases or deprivation (Pinto et al., 2023). ER describes the adaptability of individual emotional functioning, explaining differences in affective functioning and processing of emotional information during emotionally challenging situations (Pinto et al., 2023). Taking into consideration Stern's model, CR describes an active process of adaptation and compensation of brain pathology or injury (Stern, 2009). According to the SEC model, the different types of reserve may interact with each other to mitigate the impact of neuropathology (Pinto et al., 2023), being all active processes of reserve. Considering that our experiences throughout life can influence each type of reserve differently and that various disorders can impact them in distinct ways, it is crucial to develop an instrument targeting each type of reserve. Since these reserves cannot be assessed directly, it is important to consider all the main proxies in their evaluation. To the best of our knowledge, there is no previous instrument targeting SR and ER.

SR proxies

Considering that the sensory functioning involves different levels of complexity, from basic peripheral processes focused on sensory acuity to central processes that are more complex and involve higher cognitive processing as sensory perception (see Musiek and Baran, 2018; Powell et al., 2022), an instrument focused on SR should target these proxies.

ER proxies

Emotional development involves a gradual increase in the ability to experience, express, and interpret the full range of emotions, and cope appropriately with them (American Psychological Association [APA], 2023n.d.). Therefore, among the main abilities of emotional intelligence is emotional regulation (APA, 2023n.d.), which is considered the core of emotional resilience (Rogers, 2013). Resilience can be considered as a developmental process of adaptation in the face of adversity (American Psychological Association, 2017; Mestre et al., 2017). Considering that we are exposed to diverse events throughout life, including adverse events that challenge our emotional development, adaptive healthy emotion regulation strategies can enhance resilience when dealing with adversity (Artuch-Garde et al., 2017). Following a developmental perspective, the adverse life events experienced throughout life, emotional regulation strategies, and resilience, can be regarded as main proxies of ER.

CR proxies

Several proxies of CR have been identified in the literature, but different instruments focus on different proxies. Moreover, to the best of our knowledge, there is no consensus about the best way to measure them and no previous instrument used a multimeasures approach in such evaluation. For example, several measures have been used for the proxy *occupation*, namely the last occupational activity and its requirements in relation to data, people, and things. CR also seems to be higher in people engaged in more and more complex occupational activities, as well as speaking more than one language (Pinto et al., 2024). However, available instruments usually take only one or a limited number of the identified proxies into account. Additionally, personality traits such as low neuroticism or high conscientiousness are usually disregarded, even if these traits are proven to be related to better neurocognitive functioning regardless of neuropathology (Graham et al., 2021).

The main objective of this work is to propose a new instrument to evaluate reserve according to SEC model: the Sensory, Emotional, and Cognitive reserve inventory (SECri). Additionally, this work aims to explore the preliminary psychometric properties of SECri in a sample of healthy adults.

Method

SECri development

SECri was developed after Irwing and Hughes (2018) stages of test development. Concerning the first stage – construct definition, specification of test need and test structure, it was adopted the previously described SEC model (see Pinto et al., 2023), for which no previous instrument have been developed. The inventory was structured in the same domains of the model: SR, ER, and CR. The overall planning and item development involved the following steps: (1) compiling items from existing CR questionnaires; (2) organizing items by type of proxy; (3) creating new items considering the proxies of CR identified in a recent umbrella review (Pinto et al., 2024); (4) selecting items from existing instruments and creating items for SR and ER based on the definitions and the rationale proposed for the SEC model (Pinto et al., 2023); (5) organize items by domain (SR, ER, and CR), proxies, and subproxies (see Figure 1); and (6) preliminary analysis of psychometric properties of SECri.

Concerning reliability, the internal consistency was analyzed using Cronbach alpha. Further studies are needed to perform a factor analysis. In the validation stage, a think-aloud protocol was used during a pilot of the self- and informant-report versions, which allowed for adjustments in its face validity. Convergent validity between SECri domains and validated tests targeting the same domains was also estimated. The predictive validity was analyzed based on SECri's ability to predict global cognitive performance, measured through the Montreal Cognitive Assessment (MoCA) (Nasreddine et al., 2005; Portuguese version by Freitas et al., 2011) total score. Although more studies are needed to examine the psychometric characteristics of the SECri, the recommended scoring for the inventory and its domains is standardized z scores. The following intermediate specifications should be considered: use a visual analogue scale between 0 (strongly disagree) to 10 (strongly agree) for all

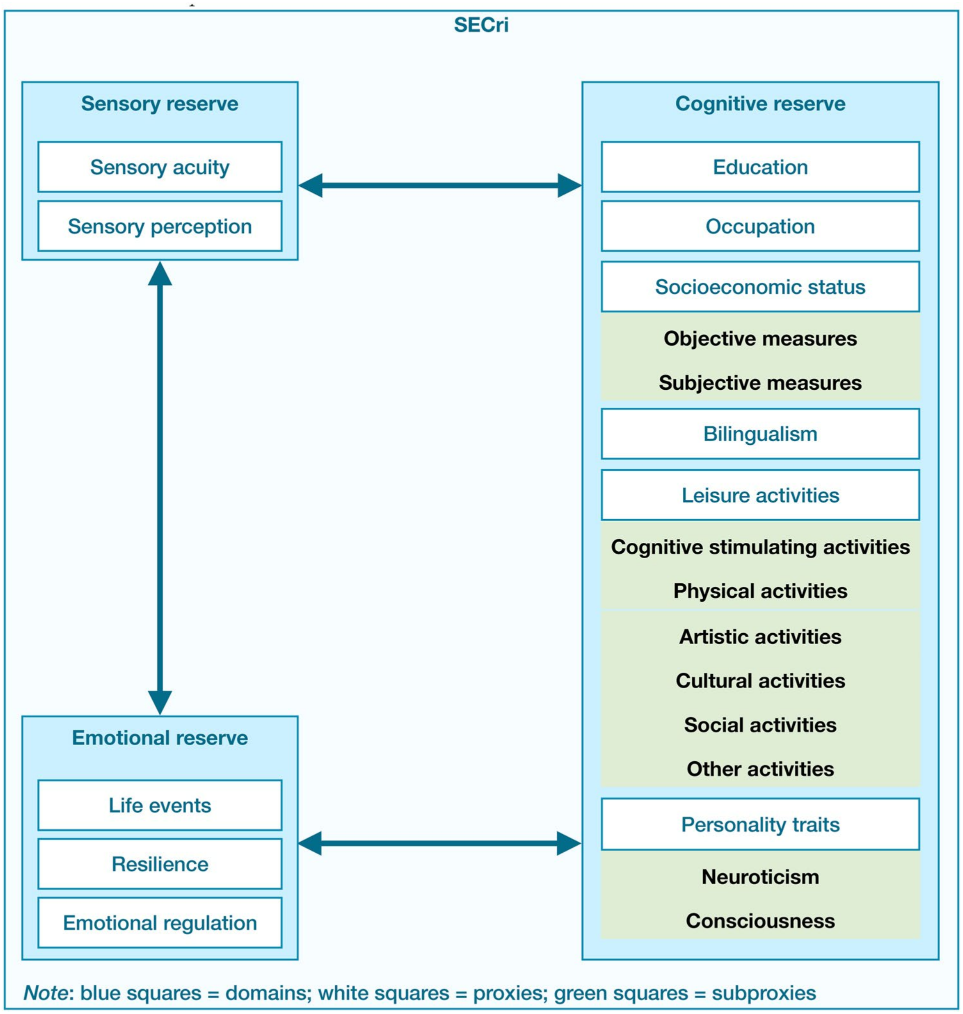

Figure 1. SECri domains and proxies.

the items that are adjustable to this scale; use the excel book provided (see Supplemental material) to code the data that are not in the previously mentioned scale and to calculate the scores for the SR, ER, and CR domains, as well as the total score; use preferably the print form format (the administration via the internet is possible, maintaining the same layout of the response form, but it was not tested). In the stage of implementation and testing, it is important to note that all the items should be responded, except the ones in which the scale is "adult age after retirement" for people not yet retired; therefore, it is indispensable to check if all items were responded. A technical manual was developed to code the data and compute the test scores (refer to Supplemental Material).

Participants

A total of 57 healthy adult participants (41 female) were recruited using a snowball method (see Table 1 for participants' characteristics). The inclusion criteria included being at least 35 years old, given that this can be considered a threshold for middle-aged adults (Medley, 1980). The exclusion criteria included reporting a prior history of substance abuse, uncorrected visual or auditory impairments, motor disorders, and a history of psychiatric disorders; being illiterate or non-native Portuguese speaker. All participants except one were right-handed. The informants were mostly family members (75%), and the others were formal caregivers. Four groups were created based on the age range (35–45, 46–55, 56–65, ≥ 66 years old). Groups did not differ in sex and years of formal education.

Instruments

The participants completed a semi-structured interview and a neurocopsychological assessment protocol. A multisensory integration task (adapted from Murray et al., 2018) and the Trait Meta-Mood Scale-24 (Salovey et al., 1995; Portuguese version by Queirós et al., 2005), an emotional intelligence scale, were administered to assess the convergent validity with the SR and ER scores on SECri, respectively. The neurocognitive assessment protocol to examine the convergent validity of the CR scores of the SECri included tests

Table 1. Descriptive statistics of sociodemographic variables.

Sociodemographic variables	Full sample ($n = 57$)	Age range ≤ 45 ($n = 13$)	46–55 ($n = 20$)	56–65 ($n = 9$)	≥ 66 ($n = 15$)
Female (% and *n*)	71.9% ($n = 41$)	76.9% ($n = 10$)	75.0% ($n = 15$)	55.6% ($n = 5$)	73.3% ($n = 11$)
Age in years ($M \pm SD$)	56.84 ± 14.66	39.92 ± 3.25	51.15 ± 2.82	59.44 ± 3.25	77.53 ± 7.62
Years of formal education ($M \pm SD$)	10.93 ± 5.46	15.00 ± 3.87	12.68 ± 4.50	10.44 ± 5.32	5.07 ± 2.56
Marital status (%)	47.4	38.5	60.0	77.8	20.0
Married	17.5	46.2	20.0	0.0	0.0
Single	12.3	15.4	10.0	11.1	13.3
Divorced	5.3	0.0	10.0	0.0	6.7
Widowed	17.5	0.0	0.0	11.1	60.0
Other					
Job situation (%)	57.9	92.3	70.0	77.8	0.0
Full-time	5.3	0.0	10.0	11.1	0.0
Part-time	28.1	0.0	0.0	11.1	100.0
Retired	7.0	7.7	15.0	0.0	0.0
Unemployed	1.8	0.0	5.0	0.0	0.0
Other					

targeting: (a) cognitive efficiency, assessed by the Symbol Digit Modalities Test (Smith, 1982; Portuguese version by Vicente et al., 2021) and the Paced Auditory Serial Addition Task (Gronwall, 1977); (b) capacity, assessed by Raven's Progressive Matrices (Raven, 1941; Portuguese version by Queiroz-Garcia et al., 2021) and Telpi (Alves et al., 2010; Alves et al., 2012); and (c) flexibility, assessed by the Modified Wisconsin Card Sorting Test (Schretlen, 2010; Portuguese version by Vicente et al., 2021), the Stroop test (Stroop, 1935; Portuguese version by Fernandes, 2013), and verbal fluency tasks (Benton & Hamsher, 1989; Portuguese version by Vicente et al., 2022).

Semi-structured interview

The semi-structured interview comprised questions concerning sociodemographic variables (sex, age, years of formal education, degree obtained), as well as inclusion and exclusion criteria (clinical conditions, history of substance abuse, uncorrected visual or auditory impairments, motor disorders, native language).

Montreal cognitive assessment (MoCA)

The MoCA (Nasreddine et al., 2005; Portuguese version by Freitas et al., 2011) is a widely used screening tool designed to detect neurocognitive impairment. The MoCA assesses several neurocognitive domains, including: (a) visuospatial/executive ability through an alternating trail making task, drawing a clock, and copying a cube task; (b) naming through a task of naming animals; (c) memory through a task of delayed recall of a list of words previously learned; (d) attention through a digit span task, a sustained attention task, and a subtraction task; (e) language through a sentence repetition and a verbal fluency task; (f) abstraction through the identification of similarities between items; and (g) temporal and spatial orientation. The MoCA takes approximately 10 minutes to administer, and the total score is calculated by summing the scores of each task, with a maximum possible score of 30 points. Higher scores on the MoCA are indicative of better cognitive performance. In the Portuguese validation, the MoCA demonstrated a Cronbach's alpha of .61 (Gonçalves et al., 2023).

Simple detection task

The simple detection task (adapted from Murray et al., 2018) is a task designed to assess multisensory integration that lasts about 5–10 minutes. In this task, participants are instructed to focus on a central fixation point on a screen and to press a designated button as soon as they detect the appearance of the visual, auditory, or audiovisual stimulus. The visual stimulus was a black circle centered against a white background, and the auditory stimulus was a 1000 Hz sinusoidal pure tone presented through headphones. The stimuli were presented at random intervals to prevent anticipation effects. Participants completed four blocks of 50 trials. Each block comprises 15 trials of each visual, auditory, and audiovisual stimulus and five trials with no stimulus. The stimulus duration was 100 ms with an inter-stimulus interval ranging between 2500-3500 ms. Reaction times are recorded for each trial, and the average reaction time is calculated as the primary outcome measure, with shorter reaction times indicating better sensory processing. The experiment was generated using SuperLab version 6.0 (Cedrus Corporation, 2021).

Trait Meta-Mood scale-24 (TMMS-24)

The TMMS-24 (Salovey et al., 1995; Portuguese version by Queirós et al. (2005) is a self-report questionnaire designed to assess individual differences in emotional intelligence, specifically focusing on the ability to reflect upon and manage one's emotions (Salovey et al., 1995). The TMMS-24 includes 24 items divided into three subscales: (a) attention to emotions, which evaluates how much individuals focus on and value their emotions; (b) clarity of emotions, which evaluates how individuals perceive and understand their emotions; and (c) repair of emotions, which evaluates how well individuals regulate and repair their emotional states. Participants rate each item on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree), indicating the extent to which they agree with statements about their emotional experiences and management. The scores for each subscale are calculated by summing the relevant items, with higher scores indicating greater emotional attention, clarity, or repair abilities. In the Portuguese validation, the TMMS-24 showed good internal consistency, with Cronbach's alphas of .88 for attention to emotion, .83 for clarity of emotions, and .92 for repair of emotions (Queirós, et al., 2005).

Symbol digit modalities test (SDMT)

The SDMT (Smith, 1982; Portuguese version by Vicente et al., 2021) provides a measure of cognitive efficiency, processing speed, attention, and motor skills. Participants are required to associate symbols for numbers according to a specific key (Smith, 1982). It includes one main task: participants are presented with a series of symbols and asked to write down the corresponding number for each symbol based on the reference key provided at the top of the page. The test lasts 90 seconds, and participants are instructed to complete as many correspondences as possible within this time frame (Vicente et al., 2021). The number of correct substitutions is calculated as the total score for the task, with higher scores indicating better cognitive processing speed and efficiency. SDMT proved test-retest reliability (>.74) in a previous study (Arango-Lasprilla et al., 2015).

Paced auditory serial addition task (PASAT)

The PASAT (Gronwall, 1977) is a measure of cognitive efficiency that also requires auditory information processing speed, calculation ability, as well as working memory. The task involves listening to a series of single-digit numbers presented at 3-second intervals and adding each new digit to the one immediately prior to it. The number of correct responses is calculated, with higher scores indicating better performance.

Raven progressive matrices (RPM)

The RPM (Raven, 1941; Portuguese version by Queiroz-Garcia et al., 2021) is a non-verbal measure of cognitive capacity that assesses abstract reasoning and fluid intelligence. The test consists of a series of diagrammatic puzzles, where participants are required to identify the missing piece that completes a pattern or sequence. The test includes multiple sets of matrices, each increasing in complexity. Scores are based on the number of correct responses, with higher scores indicating better cognitive capacity. In the Portuguese adaptation, RPM showed a Cronbach's alpha of .94 (Queiroz-Garcia et al., 2021).

Teste de leitura de palavras irregulares [irregular word reading test] (TeLPI)

The TeLPI (Alves et al., 2010; Alves et al., 2012) is a measure of premorbid cognitive capacity that assesses the ability to read words that do not follow the regular spelling rules of the language. The test involves presenting a list of 46 words and asking participants to read each word aloud. Scoring is based on the accuracy of pronunciation. TeLPI showed an internal consistency of .94 (Alves et al., 2012).

Modified Wisconsin card sorting test (M-WCST)

The M-WCST (Schretlen, 2010; Portuguese version by Vicente et al., 2021) is a neuropsychological test used to assess cognitive flexibility, abstract reasoning, and the ability to shift and maintain attention. In the WCST, participants are presented with a set of cards, each displaying figures that vary in color, shape, and number. Participants are asked to sort the cards according to categorical rules (e.g., color, shape, number) without being told the sorting rule. After each card is placed, feedback is given indicating whether the placement is correct or incorrect, allowing participants to infer the sorting rule and adjust their strategy accordingly. To complete a category, the participant must correctly place six consecutive cards, and the test continues until six categories are completed or until all the cards have been used. Key measures obtained from the M-WCST include the number of categories completed, the number of perseverative errors (repetitive errors following a previously correct rule), and the number of non-perseverative errors. Better performance on the M-WCST is indicated by more categories completed and fewer errors (Vicente et al., 2021). In this study only perseverative errors were considered for analysis.

Stroop - color and word test

The Stroop (Stroop, 1935; Portuguese version by Fernandes, 2013) provides a measure of cognitive flexibility and interference inhibition in which the processing of one stimulus characteristic is affected by another stimulus attribute (Stroop, 1935). It includes three tasks: (a) reading of color names, which is indicative of the basic speed of reading; (b) naming the color of stimulus X, which is indicative of the ability to identify color names; and (c) naming the color in which the words red, green, and blue are written, indicative of the ability to inhibit the automatic response. Each task lasts for 45 seconds, and the participant is asked to complete it as quickly as possible (Fernandes, 2013). The number of stimuli processed is calculated for each task, as well as the interference score, through the difference between the scores obtained in the third task and the estimated interference score. Higher results in the three tasks are indicative of better performance, while higher interference suggests worse inhibition ability. In the Portuguese validation, Stroop presented an internal consistency of .66 (Fernandes, 2013).

Phonemic and semantic verbal fluency

Phonemic and semantic verbal fluency tests are recommended to measure cognitive flexibility, processing speed, language production, and executive functioning (Greenaway et al., 2009). The phonemic and semantic verbal fluency test (Benton & Hamsher, 1989; Portuguese version by Vicente et al., 2022) consists of two tasks: (a) phonemic fluency in which participants are asked to generate as many words as possible beginning with a specific letter (F, A, S, and M) within a 60-second time limit, excluding proper nouns and variations of the same word; and (b) semantic fluency in which participants are asked to generate as many words as possible from a given category (animals, fruits, and professions) within 60 seconds. The total number of correct words produced is counted, while errors such as repetitions and non-category words are noted but not included in the score. Higher scores indicate better cognitive flexibility. In the

Portuguese validation, the test demonstrated adequate internal consistency for both tasks (Cronbach's alpha > .86) (Vicente et al., 2022).

Procedures

Participants were recruited between July and December 2023. All participants gave their informed consent. The participants were assessed using the previously described neuropsychological assessment protocol in a closed room. The assessment was carried out in a single session by a trained psychologist to ensure standardization of the assessment procedures. The order of administration of the instruments was counterbalanced to avoid possible effects of fatigue.

The software SPSS (version 29.0.1.1) was used for statistical analysis, with $\alpha = .05$ serving as the threshold for statistical significance. Descriptive statistics, including mean values and standard deviations (for continuous variables) and percentages (for categorical variables), were used to examine both the sociodemographic and clinical characteristics of the sample. The performance of adults within each age range was compared using ANOVA analysis.

The psychometric properties of SECri analyzed included acceptability, internal consistency, convergent validity, and predictive validity. Acceptability was assessed using missing data analyses, as well as floor and ceiling effects. Acceptability was considered adequate when the response rate per item was above 90% (Bennett, 2001), and less than 15% of participants achieved the lowest or the highest possible score (floor and ceiling effects) (McHorney & Tarlov, 1995). For the internal consistency analysis, the Cronbach's alphas were calculated for each subscale separately and also for each SECri domain (SR, ER, and CR). The internal consistency was considered adequate for Cronbach's alphas higher than .70. A Pearson correlation was calculated between SECri domains and a multisensory integration task, an emotional intelligence questionnaire, and cognitive tests to assess the convergent validity. A correlation of .10 was considered weak, between .30 and .50 moderate, and higher than .50 strong (Field, 2024). A Pearson correlation coefficient of .10 was considered indicative of a small effect, .30 represented a moderate effect, and .50 signified a large effect (Cohen, 1988). A multiple linear regression analysis was used calculate the predictive validity of SECri scores on MoCA scores.

Results

Sensory, emotional, and cognitive reserve inventory (SECri)

The SECri was developed by Pinto, Dores, Peixoto, and Barbosa based on the SEC model (Pinto et al., 2023). The inventory (see Supplemental Material) includes three domains (SR, ER, and CR), their proxies, and subproxies (see Figure 1). The SR domain includes items targeting the following proxies: (a) visual, auditory, tactile, olfactory, and gustatory acuity; and (b) sensory-perception, through items selected from the Sensory Perception Quotient-10 (SPQ-10, Greenberg et al., 2018; Rocha et al., 2018) and two additional items from the full version of this questionnaire (Tavassoli et al., 2014). The ER includes the following proxies: (a) life events evaluated using items selected from the Life Events Checklist for DSM-5 (Weathers et al., 2013); (b) resilience evaluated through items selected from the Brief Resilience Scale (da Silva-Sauer et al., 2021; Smith et al., 2008); and (c) emotional regulation evaluated using items selected from the Emotional Regulation Questionnaire (Gross & John, 2003). The CR domain includes items targeting the following proxies: (a) education; (b) work occupation; (c) socioeconomic status, (d) bilingualism; (e) leisure activities; and (f) personality traits (through eight items from NEO-Five Factor Inventory with 20 items - NEO-FFI-20; Bertoquini & Pais Ribeiro, 2006).

Descriptive statistics and age-group comparisons

Table 2 displays the descriptive statistics of the neuropsychological assessment protocol, as well as age-group comparisons. As expected, the older group presented worse cognitive performance in most neurocognitive tests and the sensory task. The groups did not differ in emotional intelligence (see Table 2).

Psychometric properties of SECri

Acceptability

Information about missing responses, floor, and ceiling effects are synthesized in Table 3 and detailed in Table 1 of Supplemental Material.

Internal consistency

The internal consistency of the SR was excellent for both self-report versions (total domain score $\alpha = .93$) and informant report ($\alpha = .98$) (see Table 3 and Table 4 in Supplemental Material).

The internal consistency of the ER was acceptable both for the self-report ($\alpha = .70$) and informant-report versions ($\alpha = .77$) (see Tables 5 and 6 in Supplemental Material).

In the CR, the internal consistency is acceptable for the self-report ($\alpha = .76$) and excellent for the informant-report version ($\alpha = .98$) (see Tables 7 and 8 in Supplemental Material). The items that, if deleted, led to a higher internal consistency, differed among both versions in all types of reserve.

The SECri total score showed lower internal consistency in the self-report ($\alpha = .45$), as well as the informant-report version ($\alpha = .53$) (see Tables 9 in Supplemental Material).

Convergent validity

Self-reported SR scores correlated negatively with the reaction time in both the auditory block ($r = -.44$; $p = .003$) and the audiovisual block ($r = -.32$; $p = .032$). Correlation coefficients were not significant in the informant-report version (see Tables 10 and 11 in Supplemental Material).

Table 2. Scores obtained in the neuropsychological assessment.

Variables	Full Sample (M ± SD)	Age ranges ≤ 45 (n = 13)	46–55 (n = 20)	56–65 (n = 9)	≥ 66 (n = 15)	F (3,53)	p	η^2
Neurocognitive tests								
MoCA	25.00 ± 3.58	27.85 ± 1.77[a]	26.15 ± 2.52[a,b]	24.33 ± 2.69[b]	21.40 ± 3.48[c]	15.12	<.001	.46
Telpi – total	34.33 ± 11.61	41.23 ± 4.95[a]	37.75 ± 7.09[a,b]	32.33 ± 15.68[b,c]	25.00 ± 12.35[c]	7.25	<.001	.29
Phonemic verbal fluency – total	44.26 ± 17.46	51.62 ± 16.04[a]	51.90 ± 13.28[a]	42.44 ± 15.72[a]	28.80 ± 15.03[b]	8.37	<.001	.32
Semantic verbal fluency – total	46.02 ± 13.83	57.62 ± 10.67[a]	50.80 ± 5.93[b]	45.44 ± 11.77[b]	29.93 ± 10.27[c]	23.30	<.001	.57
PASAT – total	39.25 ± 13.66	48.46 ± 10.67[a]	42.10 ± 11.80[a,b]	38.78 ± 13.12[a,b]	27.73 ± 11.34[b]	8.01	<.001	.31
SDMT	35.56 ± 16.08	45.77 ± 10.02[a]	42.85 ± 10.40[a]	37.33 ± 13.77[a]	15.93 ± 10.26[b]	23.25	<.001	.57
Stroop - interference	2.86 ± 7.94	−1.41 ± 11.35[a]	2.08 ± 7.23[a,b]	3.82 ± 3.42[a,b]	7.31 ± 4.83[b]	3.16	.032	.15
Raven Matrices	36.33 ± 14.14	47.15 ± 10.69[a]	42.45 ± 7.47[a,b]	36.78 ± 12.71[b]	18.53 ± 5.62[c]	29.80	<.001	.63
WCST – perseverative errors	3.30 ± 4.87	0.23 ± 0.60[a]	2.20 ± 3.07[a]	6.11 ± 5.67[b]	5.73 ± 6.44[b]	3.30	.003	.23
Emotional assessment								
TMMS – attention	29.98 ± 11.92	34.00 ± 20.18[a]	30.20 ± 8.95[a]	29.33 ± 8.59[a]	26.60 ± 6.37[a]	0.90	.447	.05
TMMS – clarity	28.46 ± 5.56	29.23 ± 3.59[a]	28.50 ± 7.74[a]	27.78 ± 5.36[a]	28.13 ± 3.70[a]	0.14	.936	.01
TMMS – repair	29.11 ± 6.47	27.77 ± 4.78[a]	31.25 ± 8.1[a]	28.89 ± 6.37[a]	27.53 ± 4.94[a]	1.23	.307	.07
TMMS - Total	87.83 ± 12.17	86.31 ± 11.69[a]	94.83 ± 9.29[b]	85.00 ± 15.15[a]	82.27 ± 10.98[a]	3.75	.017	.18
Sensorial task								
Auditory block (*ms*)	688.40 ± 282.76	453.76 ± 108.92[a]	595.08 ± 200.65[a,b]	711.38 ± 256.07[b]	973.51 ± 260.36[c]	11.59	<.001	.46
Visual block (*ms*)	829.74 ± 422.67	530.99 ± 134.49[a]	679.05 ± 288.33[a]	798.34 ± 502.02[a]	1275.68 ± 322.50[b]	11.32	<.001	.45
Auditory-visual block (*ms*)	736.29 ± 343.95	444.69 ± 67.92[a]	606.58 ± 183.59[a,b]	823.35 ± 360.18[b]	1069.92 ± 346.92[c]	11.97	<.001	.47

Note. PASAT: paced auditory serial addition test; SDMT: symbol digit modalities test; WCST : Wisconsin card sorting test; TMMS: trait meta-mood scale; a, b, c, and d: equivalence (i.e., same letter) and difference between groups (i.e., different letter).

Self-reported ER scores were positively correlated with TMMS attention (r = .27; p = .047) and repair (r = .41; p = .002). In the informant-report version, the total score in ER only correlated with TMMS repair (r = .48; p = .039) (see Tables 12 and 13 in Supplemental Material).

Self-reported CR scores positively correlated with both measures of cognitive efficiency (both $r > .58$; $p < .001$), cognitive ability tests (both $r > .67$; $p < .001$), and positively or negatively correlated with cognitive flexibility measures, depending on the tests (all $|r| > .39$; $p < .004$), except the Stroop interference. In the informant-report version, the total score in CR correlated with both measures of cognitive efficiency (both $r > .52$; $p < .021$) and cognitive ability (both $r > .52$; $p < .022$), and all cognitive flexibility tests (all $|r| > .49$; $p < .034$), except the Stroop interference (see Tables 14 and 15 in Supplemental Material).

Predictive validity

Regarding the predictive validity, a regression model including self-reported scores for SR, ER, and CR as predictors, significantly contributed to explain the MoCA total score, adj. R^2 = .281, F (3,54) = 6.655, $p < .001$. This model explained 28.1% of the variance in the total score of MoCA, with CR (**β** = .444, $p < .001$) being the only significant predictor of the MoCA score (see Table 4).

Discussion

Recently, the Sensory, Emotional, and Cognitive Reserve (SEC) model was proposed as a new and extended model of cognitive reserve (CR), emphasizing the interdependence between sensory reserve (SR), emotional reserve (ER), and CR. While much research has focused on operationalizing CR, no instrument is suitable to measure the domains of the SEC model. This study introduces the Sensory, Emotional, and Cognitive reserve inventory (SECri) to evaluate the SEC model and explores its preliminary psychometric properties in a sample of healthy adults.

The main characteristics of SECri are: (a) inclusion of self- and informant-report versions; (b) organization by reserve domains (i.e., SR, ER, and CR); (c) inclusion of items focused on all the CR proxies previously identified; (d) use of a sufficiently discriminative response scale of 11-points in most items; and (e) evaluation of reserve across the lifespan. Additionally, it is worth mentioning that even though SECri allows to compute a total score of reserve, this score is not statistically supported so far, and specific scores by each domain may provide more useful measures of active reserve for clinical purposes.

Regarding acceptability, the percentage of missing values was satisfactory for most items in all reserve domains, specifically for the self-report version. Floor and ceiling effects varied across age ranges, as expected. In effect, this result may be explained, at least in part, by the fact that some questions pertained to a specific period of life that not everyone has reached. Therefore, more studies are needed to determine whether all items are suitable for different periods of the lifespan and identify if corrected scores per age-groups are to be implemented.

Considering internal consistency indices, they were at least acceptable for all SR, ER, and CR domains. The internal consistency of the SECri total score was lower in both the self- and informant-report versions, which is not unexpected, given that the obtained values reflect the relative independence of the sensory, emotional, and cognitive measures of the inventory. Since no previous instrument has focused on SR and ER, only the internal consistency of the

Table 3. Acceptability.

Item	% missing	Floor effect	Ceilling effect
Sensory reserve Visual acuity			
Infancy and adolescence		56–65	≤ 45; 46–55; 56–65; ≥ 66
Adult age before retirement		46–55	46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46-55; 56-65; ≥ 66		
Auditory acuity			
Infancy and adolescence			≤ 45; 46–55; 56–65; ≥ 66
Adult age before retirement		46–55	≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		56–65; ≥ 66
Tactile acuity			
Infancy and adolescence			≤ 45; 46–55; 56–65; ≥ 66
Adult age before retirement			≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		≤ 45; 46–55; 56–65; ≥ 66
Olfactory acuity			
Infancy and adolescence			≤ 45; 46–55; 5665; ≥ 66
Adult age before retirement			≤ 45; 46-–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		56–65; ≥ 66
Taste acuity			
Infancy and adolescence			≤ 45; 46–55; 5-–65; ≥ 66
Adult age before retirement			≤ 45; 46–55; 5-–65; ≥ 66
Adult age after retirement	≤ 45; 46-55; 56–65; ≥ 66		≤ 45; 56–65; ≥ 66
Sensory perception item 1			
Infancy and adolescence		≥ 66	
Adult age before retirement		≥ 66	46–55
Adult age after retirement	≤ 45; 46-55; 56–65; ≥ 66	≥ 66	
Sensory perception item 2			
Infancy and adolescence			46–55; ≥ 66
Adult age before retirement			46–55
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Sensory perception item 3			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≤ 45; 46–55; 56–65; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56-65; ≥ 66	
Sensory perception item 4			
Infancy and adolescence		≤ 45; 46–55; ≥ 66	
Adult age before retirement		≤ 45; 46–55; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		
Sensory perception item 5			
Adult age before retirement			≤ 45
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		
Sensory perception item 6			
Infancy and adolescence			4655; 56-6–5; ≥ 66
Adult age before retirement			≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		56–65
Sensory perception item 7			
Infancy and adolescence		≤ 45; ≥ 66	≤ 45; ≥ 66
Adult age before retirement		≤ 45	≤ 45; 46-55
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Sensory perception item 8			
Infancy and adolescence		≥ 66	≤ 45; 56–65
Adult age before retirement			≤ 45; 46–55; 56–65
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	56–65
Sensory perception item 9			
Infancy and adolescence		≤ 45; 56–65; ≥ 66	
Adult age before retirement		≤ 45; 56–65; ≥ 66	≤ 45; 46–55
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56–65; ≥ 66	
Sensory perception item 10			
Infancy and adolescence		≤ 45; ≥ 66	≤ 45
Adult age before retirement			≤ 45
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56-65; ≥ 66	
Sensory perception item 11			
Infancy and adolescence		≥ 66	≤ 45; 56–65
Adult age before retirement			≤ 45; 46–55; 56–65
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Sensory perception item 12			
Infancy and adolescence	46–55; ≥ 66	≤ 45	≤ 45; 46–55; 56–65; ≥ 66
Adult age before retirement		56-65; ≥ 66	≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		56–65
Emotional Reserve			
Life events – item 1		≤ 45	
Life events – item 2		≤ 45; 46–55; 56–65; ≥ 66	
Life events – item 3			
Life events – item 4		≤ 45; 46–55; 56–65; ≥ 66	
Life events – item 5		≤ 45; 46–55; 56–65	
Life events – item 6		≤ 45; 46–55; 56–65; ≥ 66	
Life events – item 7		≤ 45; 46–55; 56–65; ≥ 66	

(*Continued*)

Table 3. Continued.

Item	% missing	Floor effect	Ceilling effect
Resilience – item 1			≤ 45
Emotional regulation – item 1			≤ 45
Emotional regulation – item 4			≤ 45
Cognitive reserve			
Vocational/professional training	≥ 66	≤ 45; 56–65; ≥ 66	≤ 45; 46–55
Occupational activities			≤ 45
Retirement age	≤ 45; 46–55; 56-65; ≥ 66		
Unemployment		46–55	≤ 45; 46–55; 56–65; ≥ 66
Years of formal education - mother	46-55	≤ 45; 56–65; ≥ 66	
Scholarity level - mother	46–55	≤ 45; 56–65; ≥ 66	
Years of formal education - father	46–55; ≥ 66	56–65; ≥ 66	
Scholarity level - father	46–55; ≥ 66	56–65; ≥ 66	
Occupation - father	46-55		
Income		≤ 45; 46–55; 56–65; ≥ 66	56–65
Socioeconomic difficulty			≤ 45
Language 1 – speak	≤ 45; 46–55; 56–65; ≥ 66		
Language 1 - read	≤ 45; 46–55; 56–65; ≥ 66		
Language 1 – write	≤ 45; 46–55; 56–65; ≥ 66	5-–65	
Language 2 – speak	≤ 45; 46–55; 56–65; ≥ 66		
Language 2 - read	≤ 45; 46–55; 56–65; ≥ 66		
Language 2 – write	≤ 45; 46–55; 56–65; ≥ 66		
Language 3 – speak	≤ 45; 46–55; 56–65; ≥ 66		
Language 3 - read	≤ 45; 4655; 56-–65; ≥ 66		
Language 3 - write	≤ 45; 46–55; 56–65; ≥ 66		
Leisure – item 1			
Infancy and adolescence	≥ 66	≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement	≥ 66	56–65 ≥ 66	≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		56–65; ≥ 66
Leisure – item 2			
Infancy and adolescence			≤ 45; 46–55; 56–65
Adult age before retirement		56-65	≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		
Leisure – item 3			
Infancy and adolescence			56–65; ≥ 66
Adult age before retirement		56–65; ≥ 66	56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56–65; ≥ 66	
Leisure – item 4			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		46–55; 56–65; ≥ 66	56–65
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Leisure – item 5			
Infancy and adolescence		46-55; 56-65; ≥ 66	
Adult age before retirement		≥ 66	56–65
Adult age after retirement	≤ 45; 46-55; 56-65; ≥ 66		56–65
Physical – item 1			
Infancy and adolescence			≤ 45; 46–55; 56–65; ≥ 66
Adult age before retirement			≤ 45; 46–55; 56–65; ≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Physical – item 2			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	≤ 45; 56–65
Adult age before retirement		≤ 45; 46–55; 56-65; ≥ 66	≤ 45
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56-65; ≥ 66	
Physical – item 3			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	56-65
Adult age before retirement		≤ 45; 46–55; 56–65; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56-65; ≥ 66	56–65; ≥ 66	
Artistic activities – item 1			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≤ 45; 46–55; 56-65; ≥ 66	
Adult age after retirement	≤ 45; 46-55; 56-65; ≥ 66	56–65; ≥ 66	
Artistic activities – item 2			
Infancy and adolescence		46–55; 56–65; ≥ 66	≤ 45
Adult age before retirement		≤ 45; 46–55; 56-65; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56-65; ≥ 66	
Artistic activities – item 3			
Infancy and adolescence		≤ 45; 46-55; 56-65; ≥ 66	
Adult age before retirement		≤ 45; 46-55; 56–65; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≤ 45; 56–65; ≥ 66	
Cultural activities – item 1			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≥ 66	
Adult age after retirement	≤ 45; 46–55; 56-65; ≥ 66	56–65; ≥ 66	
Cultural activities – item 2			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	

(*Continued*)

Table 3. Continued.

Item	% missing	Floor effect	Ceilling effect
Social activities – item 1			
Infancy and adolescence			≤ 45
Adult age before retirement			≤ 45
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56–65; ≥ 66	56-65; ≥ 66
Social activities – item 2			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≤ 45; 46–55; 56–65; ≥ 66	
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56-65; ≥ 66	
Social activities – item 3			
Infancy and adolescence		≤ 45; 46–55; 56–65; ≥ 66	
Adult age before retirement		≤ 45; 46–55; 56–65; ≥ 66	56-65;
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	≥ 66	
Other activities – item 1			
Infancy and adolescence		56-65	46-55; ≥ 66
Adult age before retirement		≤ 45; 46-55; 56–65	≥ 66
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66	56–65	≥ 66
Other activities – item 2			
Infancy and adolescence	≤ 45; 46–55; 56–65; ≥ 66		
Adult age before retirement	≤ 45; 46–55; 56–65; ≥ 66		
Adult age after retirement	≤ 45; 46–55; 56–65; ≥ 66		
Personality trait item 2			≤ 45; 46–55; 56–65; ≥ 66
Personality trait item 4			46–55; 56–65
Personality trait item 6			≤ 45; 46-55; 56-65; ≥ 66
Personality trait item 7			≤ 45
Personality trait item 8			≤ 45; 46–55

Table 4. Predictive validity of SECri (self-report version).

Model	*B*	*SE B*	β	*p*
MoCA				
SECRi - SR	0.386	.241	.199	.116
SECRi - ER	0.033	.114	.036	.775
SECRi - CR	0.190	.052	.444	**<.001**

Note. MoCA: montreal cognitive assessment; SECri: sensory, emotional, and cognitive reserve inventory; SR: senosry reserve; ER: emotional reserve; CR: Cognitive reserve.

CR domain of SECri can be compared to existing questionnaires. The self-reported version of this domain shows lower internal consistency than previous instruments (Sobral et al., 2014; Tomás 2020), but acceptable, nonetheless.

The analysis of convergent validity revealed a negative correlation between the self-reported SECri scores and auditory and audiovisual reaction times in a multisensory task. Given the important role of auditory and dual-sensory impairment (visual and auditory) as risk factors for neurocognitive decline (Hu et al., 2022), higher SR is expected to be associated with a faster reaction time.

ER scores in the self-reported version of the SECri were significantly correlated with attention and repair of emotions scores of the emotional intelligence questionnaire. The fact that ER scores did not correlate with clarity of emotions leads us consider the possibility of adding items to this domain, namely to include processing of emotions that seems to be affected by brain aging (Durbin et al., 2020). Additionally, ER items did not focus on different life periods, contrary to SR and most CR items. Considering the dynamic nature of reserve (Cabeza et al., 2018; Stern et al., 2020), future versions of SECri may include items targeting the development of ER through the lifespan.

Self- and informant-report scores of the CR correlated with neurocognitive tests targeting cognitive efficiency, cognitive ability, and cognitive flexibility. This outcome proved that the CR domain of SECri is aligned with the concept of CR proposed by Stern et al. (2020).

Concerning predictive validity, self-reported scores on SR, ER, and CR significantly explain a small variance in Montreal Cognitive Assessment (MoCA) total score. However, it is worth mentioning that the CR score was a significant predictor of the MoCA scores, and the fact that SR and ER do not predict the variance of MoCA scores is congruent with the cognitive measures provided by the latter.

The regression coefficient obtained for the CR domain is also consistent with previous models defining (Stern et al., 2020) and assessing CR (Reed et al., 2010). According to the latent variable model, CR can be measured by the variance in a cognitive measure (e.g., episodic memory) that is not predicted by demographic variables or brain alterations (Reed et al., 2010). Therefore, it is expected that CR scores only moderately explain the variance in MoCA scores.

The main limitations of this study are the small sample size and the need to recode several items for the analysis of each domain. Additionally, using only the MoCA to assess predictive validity may be limited, as it disregards items taping affective functioning. Despite of the previous limitations, this study provided a new inventory that has potential to improve prognosis in the clinical practice of neuropsychology. Additionally, this work has the advantage of studying reserve across the lifespan, which may be an important step to increase longitudinal studies considering reserve.

Releasing the inventory at its early stage of development aligns with the principles of open science, enabling independent research groups to study it and begin exploring its potential in diverse clinical conditions. Therefore, we encourage researchers to provide feedback on this version, contributing to its ongoing improvement. One important point that deserve attention of future research is the interpretation of SECri scores, particularly in the context of neurocognitive disorders. We hypothesize that the scores in these different types of reserve will differ depending on the main symptoms of the disorder and the severity of the disorder, which emphasizes the relevance of domain scores in contrast to the total score. For example, SR is expected to be lower and more affected in patients with Major Neurocognitive Disorder with Lewy bodies in which visual hallucinations are common (Nara et al., 2022), while ER is expected to be lower in behavioral variant of Major Frontotemporal Neurocognitive Disorder in which emotional experience and regulation seem to be compromised (Shdo et al., 2022).

Future studies may consider the following recommendations: (a) determining SECri psychometric properties in clinical and subclinical conditions; (b) determining its sensitivity to mild and major neurocognitive disorders; (c) determining cutoff scores for CR according to age and severity of neurocognitive impairment; (d) determining in which circumstances self- and/or informant-report versions are more reliable; and (e) testing the best scoring procedure of the online version to maximize assessment accuracy.

Disclosure statement

No potential conflict of interest was reported by the author(s).The other authors have no relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript. This includes employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties.

Funding

Artemisa Dores is a researcher of School of Health, Polytechnic Institute of Porto, Porto, Portugal, supported by FCT - Fundação para a Ciência e Tecnologia [Portuguese Foundation for Science and Technology] through R&D Units funding (UIDB/05210/2020).

ORCID

Joana O. Pinto http://orcid.org/0000-0002-0643-8439

References

Alves, L., Martins, C., & Simões, M. R. (2010). Avaliação da Inteligência Pré-Mórbida: Desenvolvimento da versão experimental do Teste de Leitura de Palavras Irregulares (TeLPI) para a população portuguesa. *Psychologica*, *53*(53), 299–312. https://doi.org/10.14195/1647-8606_53_14

Alves, L., Simões, M. R., & Martins, C. (2012). The estimation of premorbid intelligence levels among Portuguese speakers: The Irregular Word Reading Test (TeLPI). *Archives of Clinical Neuropsychology: The Official Journal of the National Academy of Neuropsychologists*, *27*(1), 58–68. https://doi.org/10.1093/arclin/acr103

American Psychological Association. (2017). *The Road to Resilience*. Available online at: http://www.apa.org/helpcenter/road-resilience.aspx

American Psychological Association. (n.d). Emotional development. In *APA dictionary of psychology*. Retrieved September 03, 2024, from https://dictionary.apa.org/emotional-development

American Psychological Association. (n.d). Emotional intelligence. In *APA dictionary of psychology*. Retrieved September 03, 2024, from https://dictionary.apa.org/emotional-intelligence

Arango-Lasprilla, J. C., Rivera, D., Aguayo, A., Rodríguez, W., Garza, M. T., Saracho, C. P., Rodríguez-Agudelo, Y., Aliaga, A., Weiler, G., Luna, M., Longoni, M., Ocampo-Barba, N., Galarza-del-Angel, J., Panyavin, I., Guerra, A., Esenarro, L., García de la Cadena, P., Martínez, C., & Perrin, P. B. (2015). Trail making test: normative data for the Latin American Spanish speaking adult population. *NeuroRehabilitation*, *37*(4), 639–661. https://doi.org/10.3233/NRE-151284

Artuch-Garde, R., González-Torres, M. D. C., de la Fuente, J., Vera, M. M., Fernández, Cabezas, M., & López-García, M. (2017). Relationship between resilience and self- regulation: A study of spanish youth at risk of social exclusion. *Frontiers in Psychology*, *8*, 612. https://doi.org/10.3389/fpsyg.2017.00612

Bennett, D. A. (2001). How can I deal with missing data in my study? *Australian and New Zealand Journal of Public Health*, *25*(5), 464–469. https://doi.org/10.1111/j.1467-842X.2001.tb00294.x

Benton, A. L. & Hamsher K. (1989). *Multilingual aphasia examination*. AJA Associates.

Bertoquini, V., & Pais Ribeiro, J. (2006). Estudo de formas muito reduzidas do Modelo dos Cinco Fatores da Personalidade. *Psychologica*, *43*, 193–210.

Cabeza, R., Albert, M., Belleville, S., Craik, F. I. M., Duarte, A., Grady, C. L., Lindenberger, U., Nyberg, L., Park, D. C., Reuter-Lorenz, P. A., Rugg, M. D., Steffener, J., & Rajah, M. N. (2018). Maintenance, reserve and compensation: the cognitive neuroscience of healthy ageing. *Nature Reviews. Neuroscience*, *19*(11), 701–710. https://doi.org/10.1038/s41583-018-0068-2

Cedrus Corporation. (2021). *SuperLab (Version 6.0)* [Computer software]. Cedrus Corporation. https://cedrus.com/superlab

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* (2nd ed.). Hillsdale, Erlbaum.

Durbin, K. A., Rastegar, S., & Knight, B. G. (2020). Effects of age and mood on emotional face processing differ depending on the intensity of the facial expression*Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, *27*(6), 902–917. https://doi.org/10.1080/13825585.2019.1700900

Fernandes, S. (2013). *Stroop—Teste de Cores e Palavras*. Cegoc.

Field, A. (2024). *Discovering statistics using IBM SPSS statistics*. Sage publications limited.

Freitas, S., Simões, M. R., Alves, L., & Santana, I. (2011). Montreal cognitive assessment (MoCA): Normative study for the Portuguese population. *Journal of Clinical and Experimental Neuropsychology*, *33*(9), 989–996. https://doi.org/10.1080/13803395.2011.589374

Gonçalves, J., Gerardo, B., Nogueira, J., Afonso, R. M., & Freitas, S. (2023). Montreal cognitive assessment (MoCA): An update normative study for the Portuguese population. *Applied Neuropsychology. Adult*, *14*, 1–7. https://doi.org/10.1080/23279095.2023.2252949

Graham, E. K., James, B. D., Jackson, K. L., Willroth, E. C., Boyle, P., Wilson, R., Bennett, D. A., & Mroczek, D. K. (2021). Associations between personality traits and cognitive resilience in older adults. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, *76*(1), 6–19. https://doi.org/10.1093/geronb/gbaa135

Greenaway, M. C., Smith, G. E., Tangalos, E. G., Geda, Y. E., & Ivnik, R. J. (2009). Mayo older Americans normative studies: Factor analysis of an expanded neuropsychological battery. *The Clinical Neuropsychologist*, *23*(1), 7–20. https://doi.org/10.1080/13854040801891686

Greenberg, D. M., Warrier, V., Allison, C., & Baron-Cohen, S. (2018). Testing the empathizing–systemizing theory of sex differences and the extreme male brain theory of autism in half a million people. *Proceedings of the National Academy of Sciences of the United States of America*, *115*(48), 12152–12157. https://doi.org/10.1073/pnas.1811032115

Gronwall, D. M. (1977). Paced auditory serial-addition task: A measure of recovery from concussion. *Perceptual and Motor Skills*, *44*(2), 367–373. https://doi.org/10.2466/pms.1977.44.2.367

Gross, J. J., & John, O. P. (2003). Individual differences in two emotion regulation processes: Implications for affect, relationships, and well-being. *Journal of Personality and Social Psychology*, *85*(2), 348–362. https://doi.org/10.1037/0022-3514.85.2.348

Harrison, S. L., Sajjad, A., Bramer, W. M., Ikram, M. A., Tiemeier, H., & Stephan, B. C. (2015). Exploring strategies to operationalize cognitive reserve: A systematic review of reviews. *Journal of Clinical and Experimental Neuropsychology*, *37*(3), 253–264. https://doi.org/10.1080/13803395.2014.1002759

Hu, W., Wang, Y., Wang, W., Zhang, X., Shang, X., Liao, H., Chen, Y., Huang, Y., Zhang, X., Tang, S., Yu, H., Yang, X., He, M., & Zhu, Z. (2022). Association of visual, hearing, and dual sensory impairment with incident dementia. *Frontiers in Aging Neuroscience*, *14*, 872967. https://doi.org/10.3389/fnagi.2022.872967

IBM Corp. (2023). IBM SPSS Statistics for MacOS (Version 29.0.1.1) [Computer software]. *IBM Corp*.

Irwing, P., & Hughes, D. J. (2018). Test development. In P. Irwing, T. Booth, & D. L. Hughes (Eds.), *The Wiley handbook of psychometric testing: A multidisciplinary reference on survey, scale and test development.* (pp. 3–47). John Wiley & Sons.

León, I., Garcia, J., & Roldan-Tapia, L. (2011). Construccion de la escala de reserva cognitiva en poblacion espanola: estudio piloto [Development of the scale of cognitive reserve in Spanish population: a pilot study]. *Revista De Neurologia*, *52*(11), 653–660.

León, I., García-García, J., & Roldán-Tapia, L. (2014). Estimating cognitive reserve in healthy adults using the cognitive reserve scale. *PLOS One*, *9*(7), e102632. https://doi.org/10.1371/journal.pone.0102632

McHorney, C. A., & Tarlov, A. R. (1995). Individual-patient monitoring in clinical practice: Are available health status surveys adequate? *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *4*(4), 293–307. https://doi.org/10.1007/BF01593882

Medley, M. L. (1980). Life satisfaction across four stages of adult life. *International Journal of Aging & Human Development*, *11*(3), 193–209. https://doi.org/10.2190/D4LG-ALJQ-8850-GYDV

Mestre, J. M., Núñez-Lozano, J. M., Gómez-Molinero, R., Zayas, A., & Guil, R. (2017). Emotion regulation ability and resilience in a sample of adolescents from a Suburban area. *Frontiers in Psychology*, *8*, 1980. https://doi.org/10.3389/fpsyg.2017.01980

Murray, M. M., Eardley, A. F., Edginton, T., Oyekan, R., Smyth, E., & Matusz, P. J. (2018). Sensory dominance and multisensory integration as screening tools in aging. *Scientific Reports*, *8*(1), 8901. https://doi.org/10.1038/s41598-018-27288-2

Musiek, F., & Baran, J. (2018). The auditory system: Anatomy, physiology, and clinical correlate (2nd ed). Plural Publishing.

Nara, S., Fujii, H., Tsukada, H., & Tsuda, I. (2022). Visual hallucinations in dementia with Lewy bodies originate from necrosis of characteristic neurons and connections in three-module perception model. *Scientific Reports*, *12*(1), 14172. https://doi.org/10.1038/s41598-022-18313-6

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J. L., & Chertkow, H. (2005). The montreal cognitive assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society*, *53*(4), 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x

Nucci, M., Mapelli, D., & Mondini, S. (2012). Cognitive reserve index questionnaire (CRIq): A new instrument for measuring cognitive reserve. *Aging Clinical Experimental. Research*, *24*(3), 218–226. https://doi.org/10.3275/7800

Pinto, J. O., Peixoto, B., Dores, A. R., & Barbosa, F. (2023). A model of sensory, emotional, and cognitive reserve. *Applied Neuropsychology. Adult*, *20*, 1–3. https://doi.org/10.1080/23279095.2023.2291480

Pinto, J. O., Peixoto, B., Dores, A. R., & Barbosa, F. (2024). Measures of cognitive reserve: An umbrella review. *The Clinical Neuropsychologist*, *38*(1), 42–115. https://doi.org/10.1080/13854046.2023.2200978

Queirós, M. M., Fernández-Berrocal, P., Extremera, N. C., & J. M. C. e Queirós, P. S. (2005). Validação e fiabilidade da versão portuguesa modificada da Trait Meta- Mood Scale. *Revista De Psicologia, Educação e Cultura*, *9*(1), 199–216.

Queiroz-Garcia, I., Espirito-Santo, H., & Pires, C. (2021). Psychometric properties of the Raven's standard progressive matrices in a Portuguese sample. *Portuguese. Journal of Behavioral and Social Research*, *7*(1), 84–101. https://doi.org/10.31211/rpics.2020.7.1.210

Rami, L., Valls-Pedret, C., Bartrés-Faz, D., Caprile, C., Solé-Padullés, C., Castellvi, M., Olives, J., Bosch, B., & Molinuevo, J. L. (2011). Cuestionario de reserva cognitiva. Valores obtenidos en poblacion anciana sana y con enfermedad de Alzheimer [Cognitive reserve questionnaire. Scores obtained in a healthy elderly population and in one with Alzheimer's disease]. *Revista De Neurologia*, *52*(4), 195–201.

Raven, J. C. (1941). Standardization of progressive matrices, 1938. *British Journal of Medical Psychology*, *19*(1), 137–150. https://doi.org/10.1111/j.2044-8341.1941.tb00316.x

Reed, B. R., Mungas, D., Farias, S. T., Harvey, D., Beckett, L., Widaman, K., Hinton, L., & DeCarli, C. (2010). Measuring cognitive reserve based on the decomposition of episodic memory variance. *Brain: a Journal of Neurology*, *133*(Pt 8), 2196–2209. https://doi.org/10.1093/brain/awq154

Rocha, N., Alves, M., & Rocha, S. (2018). Quociente de Perceção Sensorial para Adultos– adaptação portuguesa. https://docs.autismresearchcentre.com/tests/SPQ_Portuguese.pdf

Rogers, P. (2013). Rethinking resilience: Articulating community and the UK riots. *Politics*, *33*(4), 322–333. https://doi.org/10.1111/1467-9256.12033

Salovey, P., Mayer, J. D., Goldman, S. L., Turvey, C., & Palfai, T. P. (1995). Emotional attention, clarity, and repair: Exploring emotional intelligence using the Trait Meta-Mood Scale. In J. W. Pennebaker (Ed.), *Emotion, disclosure, & health.* (pp. 125–154). American Psychological Association. https://doi.org/10.1037/10182-006

Schretlen, D. J. (2010). *M-WCST (Modified Wisconsin Card Sorting Test). Psychological Assessment Resources*,.

Shdo, S. M., Roy, A. R. K., Datta, S., Sible, I. J., Lukic, S., Perry, D. C., Rankin, K. P., Kramer, J. H., Rosen, H. J., Miller, B. L., Seeley, W. W., Holley, S. R., Gorno, Tempini, M. L., & Sturm, V. E. (2022). Enhanced positive emotional reactivity in frontotemporal dementia reflects left-lateralized atrophy in the temporal and frontal lobes. *Cortex; a Journal Devoted to the Study of the Nervous System and Behavior*, *154*, 405–420. https://doi.org/10.1016/j.cortex.2022.02.018

da Silva-Sauer, L., de la Torre-Luque, A., Smith, B. W., C M C Lins, M., Andrade, S., & Fernández-Calvo, B. (2021). Brief resilience scale (BRS) Portuguese version: Validity and metrics for the older adult population. *Aging & Mental Health*, *25*(8), 1554–1563. https://doi.org/10.1080/13607863.2020.1753015

Smith, A. (1982). *Symbol Digits Modalities Test*. Western Psychological Services.

Smith, B. W., Dalen, J., Wiggins, K., Tooley, E., Christopher, P., & Bernard, J. (2008). The brief resilience scale: Assessing the ability to bounce back. *International Journal of Behavioral Medicine*, *15*(3), 194–200. https://doi.org/10.1080/10705500802222972

Sobral, M., Pestana, M. H., & Paúl, C. (2014). Measures of cognitive reserve in Alzheimer's disease. *Trends in Psychiatry and Psychotherapy*, *36*(3), 160–168. https://doi.org/10.1590/2237-6089-2014-0012

Stern, Y. (2009). Cognitive reserve. *Neuropsychologia*, *47*(10), 2015–2028. https://doi.org/10.1016/j.neuropsychologia.2009.03.004

Stern, Y., Arenaza-Urquijo, E. M., Bartrés-Faz, D., Belleville, S., Cantilon, M., Chetelat, G., Ewers, M., Franzmeier, N., Kempermann, G., Kremen, W. S., Okonkwo, O., Scarmeas, N., Soldan, A., Udeh-Momoh, C., Valenzuela, M., Vemuri, P., & Vuoksimaa, E., (2020). Whitepaper: Defining and investigating cognitive reserve, brain reserve, and brain maintenance. *Alzheimer's & Dementia: The Journal of the Alzheimer's Association*, *16*(9), 1305–1311. https://doi.org/10.1016/j.jalz.2018.07.219

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*(6), 643–662. https://doi.org/10.1037/h0054651

Tavassoli, T., Hoekstra, R. A., & Baron-Cohen, S. (2014). The sensory perception quotient (SPQ): development and validation of a new sensory questionnaire for adults with and without autism. *Molecular Autism*, *5*(1), 29. https://doi.org/10.1186/2040-2392-5-29

Tomás, M. G. (2020). [*Influência da reserva cognitiva no funcionamento cognitivo de idosos portugueses*]. [Master's thesis]. Universidade de Lisboa (Portugal)).

Vicente, S. G., Rivera, D., Barbosa, F., Gaspar, N., Dores, A. R., Mascialino, G., & Arango-Lasprilla, J. C. (2021). Normative data for tests of attention and executive functions in a sample of European

Portuguese adult population. *Neuropsychology, Development, and Cognition. Section B, Aging, Neuropsychology and Cognition*, *28*(3), 418–437. https://doi.org/10.1080/13825585.2020.1781768

Vicente, S. G., Benito-Sánchez, I., Barbosa, F., Gaspar, N., Dores, A. R., Rivera, D., & Arango-Lasprilla, J. C. (2022). Normative data for verbal fluency and object naming tests in a sample of European Portuguese adult population. *Applied Neuropsychology. Adult*, *29*(5), 1268–1279. https://doi.org/10.1080/23279095.2020.1868472

Weathers, F. W., Blake, D. D., Schnurr, P. P., Kaloupek, D. G., Marx, B. P., Keane,., & T., M. (2013). *The Life Events Checklist for DSM-5 (LEC-5)*. Instrument available from the National Center for PTSD. https://www.ptsd.va.gov/professional/assessment/te- measures/life_events_checklist.asp