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Cognitive Reserve in Elderly and Its Connection with Cognitive Performance: A Systematic Review

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Abstract The cognitive reserve may delay impairments in the normal aging process, improving the resilience in cognitive functioning. The main objective of this study was to investigate, through a systematic review, which variables form the cognitive reserve. Furthermore, the association between the cognitive reserve and the cognitive functioning was also verified. Three judges searched for articles in PsycINFO, Pubmed and Scopus databases. The Cochrane recommendations, which offer directions for systematic reviews and meta-analysis, were utilized. Six surveys were gathered following the criteria of inclusion and exclusion. Studies indicate that gender, age, individual's education, parents' education, profession, reading activity, social engagement and humor are the main variables of the cognitive reserve. Education was the most assessed

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variable in the studies, followed by profession. It was concluded that the main cognitive reserve variable is education and that there is a significant correlation with a healthy cognitive maturation in the elderly.

Keywords Cognitive reserve · Cognitive functioning · Ageing · Elderly

Introduction

There are expected cognitive changes in normal aging (Carvalho et al. 2010), some of them also pathological, which can start with mild cognitive impairment and progress to dementia (Curado 2013) Cognitive reserve (CR) consists of delaying cognitive impairments from the neurodegenerative process of normal aging, increasing the resilience of cognitive functioning (Sobral et al. 2014; Ward et al. 2015). Among the most significant changes in the cognitive functioning of the elderly, studies indicate slowing in the speed of information processing as the years pass (Malloy-Diniz et al. 2013; Lezak et al. 2013). Two models describe CR. The passive, also named as cerebral or neural reserve, is characterized by the integrity of the brain structures. The brain has a greater tolerance to develop pathology, before clinical symptoms appears (Stern 2012) and refers to structural aspects of the brain such as the size and counting of synapses (Nucci et al. 2012). The active model consists of an active intention of the brain to minimize brain damage, using cognitive or compensatory processes (Stern 2002). Thus, CR in the active model may be a variable that explains the discrepancy between the individual's cerebral pathology and its clinical manifestation (Barulli et al. 2013).

A set of factors present throughout life may explain the differences in CR in individuals (Stern 2016). Although there is no consensus on which components are involved in CR, some studies indicate that within the active model, education, professional activity, intelligence and participation in leisure activities that stimulate cognition are contributing factors (Stern 2002). Other featured components are reading, writing, playing a musical instrument, studying languages, traveling, physical activity, feeding and social interaction (Leon et al. 2014; Nucci et al. 2012; Scarmeas et al. 2009). On the other hand, components which seem to have a negative association with cognitive reserve are humor, i.e., depression, propensity to boredom and loneliness (Conroy et al. 2010; Opdebeeck et al. 2015).

It is observed some efforts to develop capable scales in order to evaluate some of the active components of CR, as in the case of the Cognitive Reserve Scale developed by León et al. (2011). This scale was elaborated for the Spanish population and it has evidence of validity, with a Cronbach alpha of 0.77. The Cognitive Reserve Index Questionnaire test was developed by Nucci et al. (2012) and it seeks to evaluate active components of CR.

The CR works as a protective factor against cognitive decline and dementia (Marioni et al. 2012), demonstrating greater resistance to pathologies related to brain aging (Zahodne et al. 2015). In the study by Prince et al. (2012), for example, it was found that higher levels of education and involvement in professional activities are associated with a lower incidence of dementia in the elderly. Elderly individuals with complete higher education are less probable to have cognitive impairment when compared to individuals with lower education. High educational level in consonance with the

frequent practice of reading are predictors of better cognitive functioning in the elderly (Contador et al. 2015). It is also observed that elderly individuals with high education have a better performance in tests of cognitive flexibility and capacity of updating (Simon et al. 2015).

The CR is a hypothetical construct and, as a result, still does not present a specific measurement, with no consensus about all the variables that are part of this construct. Thus, the main objective of this study was to investigate, through a systematic review, which variables compose CR in the elderly. In addition, the relationship of the components of CR with the cognitive functioning of the elderly was verified.

Method

The present study followed recommendations of Cochrane, aiming to guide the development of systematic reviews of the literature (Higgins and Green 2008). Cochrane Data base of Systematic Review (CDSR) was utilized in the research. Data Base of Abstracts of Reviews of Effects (DARE) was utilized in order to verify the existence of previous systematic review about the subject. In these searches, no specific studies about the subject were found.

In the process of constructing the string, several tests were performed with different descriptors in order to contemplate the largest number of studies about the subject. For the construction of the string, tools as TermFinder for the PsychINFO database and the Medical Subject Headings (MeSH) index of the Pubmed/Medline database were utilized. The final version of the search string for English articles was “Cognitive Reserve” AND “Cognition” AND “Elderly”.

Peer review was utilized as search restrictor, and the descriptors should be presented in the abstract or in the title of the articles. In the search process of the articles, quotation marks were utilized in each descriptor. The search in the databases was made by researcher and two judges, included in the review only those articles that presented the entire criteria of inclusion. This procedure was performed on July 7, 2015. Regarding the year of publication of the articles, articles published in the last five years, from 2011 to 2015, were utilized as restrictors for being considered more recent studies.

The criteria of inclusion utilized were: (1) empirical articles; (2) Articles written in Portuguese, Spanish or English; (3) articles that included the three descriptors in the abstract; (4) studies with only elderly individuals. These criteria were applied through the reading of the title and the abstract of articles. The criteria of exclusion were: (1) duplicate articles; (2) articles that contained the word “cognitive reserve”, without evaluation.

The researchers independently analyzed the relevant articles and issued an opinion about their inclusion or exclusion in the review. In cases where there were divergences of opinion a third judge was contacted. After the process of selecting the studies and defining which articles would be included in the review, the researchers tabulated the data.

When searching the string terms in the PsycINFO, Pubmed and Scopus databases, 118 articles available were found. Then the abstracts were read and 97 articles were removed for not meet the inclusion criteria, leaving 21 potentially relevant articles, which were read integrally. Finally, 15 articles were removed for met the exclusion

criteria, resulting in a final bank of six articles for the present study. In addition, a fluxogram (Fig. 1) of the process of obtaining articles is presented.

Results

The data of the studies included in systematic review is presented in Table 1. It summarily presents the authorship of articles, the country where the research was done, objectives, instruments, interventions made and, finally, the main findings.

The six articles analyzed included 14.210 participants over 60 years old: 8.440 (59%) female and 5.686 (41%) male. The greatest age found was 102 years old (M = 72,7 years) (Conroy et al. 2010). The articles were published between 2010 and 2014. It was observed a prevalence of women involved in research in all articles, except one that did not specified the number of men and women (Bruno et al. 2014).

The participants were mostly recruited in the community. Only two studies recruited clinical elderly individuals, from Family Health Service and Service of Neurology from Valencian Health Agency, respectively (Marioni et al. 2012; Moral et al. 2013). In relation to design, five articles presented transversal and longitudinal cross sections (Marioni et al. 2012).

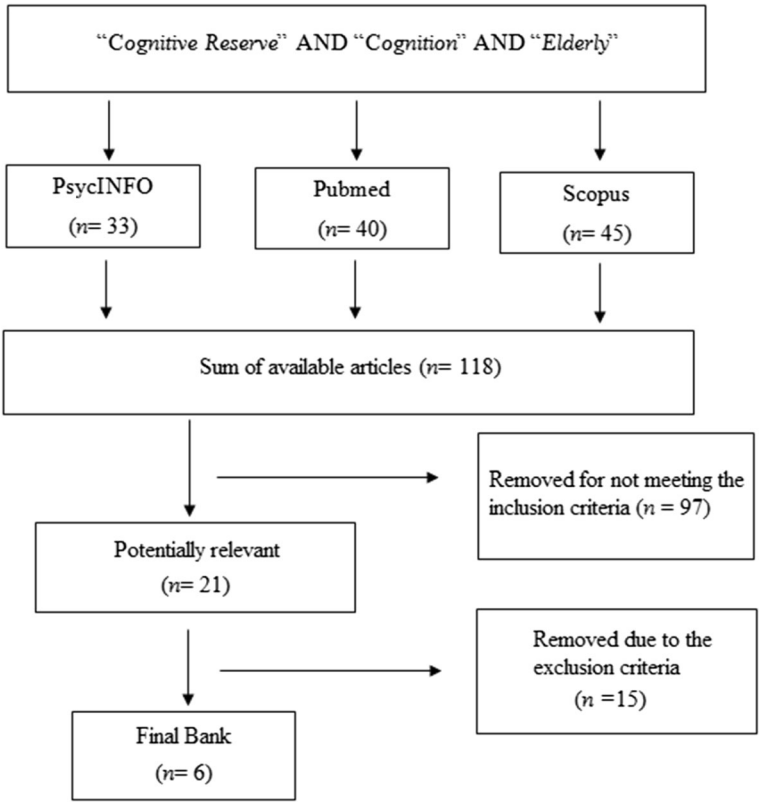

Fig. 1 Fluxogram about the process of obtaining articles

Table 1 Information about articles found

Author, year and country	*N*, gender and age	Education	Objective	Instruments	Main Findings
Conroy et al. (2010), United Kingdom.	*N* = 749	*N* = 404 up 9 years of study.	To examine the relation of the variables: education, humor (propensity to boredom, loneliness and depression) in cognitive functioning.	FDS	The variables propensity to boredom, loneliness and depression were related to worse cognitive functioning.
	W = 399 M = 350 Age 65–102 Average = 74,2	*N* = 345 over 9 years of study.		AMT HADS Depression Subscale Structured Interview	Fewer years of education were associated with a decrease in cognitive functioning.
Marioni et al. (2012), United Kingdom.	*N* = 12.492 W = 7460 *M* = 5032 Age ≥ 65 Average = 75,2 (*DP* = 6,9)	Nonexistent datum	To verify the association between the variables education, professional activity and social engagement in cognitive functioning.	MMSE CLS	High indexes in the variables education, professional activity and social engagement are associated with a better cognitive functioning.
López-Higes et al. (2013), Espain.	*N* = 83 W = 44 M = 39 Age = de 60 a 75 Average age = 64,8 (*DP* = 4,3)	*N* = 50 up 9 years of study. *N* = 33 over 9 years of study.	To determine the variables that influence the cognitive reserve and their relation to cognitive functioning.	ESB MMSE CRC BNT FDS	The variables education, parental education, professional activity and reading activity are related to cognitive functioning.

Table 1 (continued)

Author, year and country	*N*, gender and age	Education	Objective	Instruments	Main Findings
Moral et al. (2013), Espain.	*N* = 178	*N* = 111	To compare elderly with high and low cognitive reserve. In particular, the variables vocabulary, education and professional activity.	WAIS III – subtest vocabulary MMSE FDS	When comparing the two groups (high and low cognitive reserve), were found significant differences among all variables: age, gender, education and professional activity.
	W = 101	*N* = 37 no studies			
	M = 77	*N* = 36 with primary education			
	Age ≥ 65 years old	*N* = 14 with secondary education			
	Average = 74,3 (*DP* = 6,9)	*N* = 24 with higher education			
Ribeiro et al. (2013), Brazil	*N* = 624	*N* = 234 up 9 years of study.	To investigate the association between the variable professional activity and cognitive functioning.	MEEM Semi structured interview	The complexity of professional activity is associated with improved cognitive functioning.
	W = 436	*N* = 390 over 9 years of study.			
	M = 188				
	Age ≥ 65				
Bruno et al. (2014), United States of America.	*N* = 84	10 to 21 years of study.	To investigate whether cognitive reserve is related to age and cognitive functioning.	MERI TMT MMSE HDS	Education has a moderating effect between age and cognitive functioning. Elderly individuals with more years of education remember more words compared to elderly individuals with fewer years of education.
	Age: 60–88	Average = 16,4 (DP = 2,6)			
	Average = 75,1 (*DP* = 6,6)				

W = Women; M = Men; Sociodemographic Data Sheet (SDS); Memory Evaluation Research Initiative (MERI); Trail Making Test (TMT); Mini-Mental State Examination (MMSE); Abbreviated Mental Test (AMT); Hospital Anxiety and Depression (HADS); Cognitive Lifestyle Score (CLS); ECCO Senior de Boston (ESB); Cuestionario de Reserva Cognitiva (CRC); Boston Nomination Test (BNT); Wechsler Adult Intelligence Scale (WAIS-III); Hamilton Depression Scale (HDS)

In relation to the country of origin of articles, one of them is from Brazil (Ribeiro et al. 2013), two are from Spain (López-Higes et al. 2013; Moral et al. 2013), two from United Kingdom (Conroy et al. 2010; Marioni et al. 2012) and one from the United States of America (Bruno et al. 2014).

The variables identified in the articles with greater frequency in relation to CR were, respectively, education (Bruno et al. 2014; Conroy et al. 2010; López-Higes et al. 2013; Marioni et al. 2012; Moral et al. 2013;), professional activity (López-Higes et al. 2013; Marioni et al. 2012; Moral et al. 2013; Ribeiro et al. 2013), sociodemographic data: age (Bruno et al. 2014; Moral et al. 2013), gender (female or male) (Moral et al. 2013) and parents' education (López-Higes et al. 2013). The variables reading activity (López-Higes et al. 2013), social engagement (Marioni et al. 2012) and humor (propensity to boredom, loneliness and depression) (Conroy et al. 2010) were also investigated.

The level of education of elderly individuals presented average and standard deviation in one article, which obtained an average number of 16,4 years of study (*DP* = 2,6) (Bruno et al. 2014). Three studies distributed the education of participants in two categories. 688 participants up 9 years of study and 768 had over 9 years of study (Conroy et al. 2010; López-Higes et al. 2013; Ribeiro et al. 2013) and one study did not present the education of participants (Marioni et al. 2012).

Discussion

This study aimed to identify the variables that compose the CR and its influence in cognitive function of elderly individuals. Through evaluation of articles found, it was identified that age, gender, individuals' education, parents' education, professional activity, reading activity, humor (propensity to boredom, loneliness and depression) and social engagement are considered variables that compose CR.

The main finding of the study highlights education as the most favorable and influential component of CR in cognition of elderly individuals. The variable education was measured in five of six articles included (Bruno et al. 2014; Conroy et al. 2010; López-Higes et al. 2013; Marioni et al. 2012;; Moral et al. 2013;). Invariably, it was found that education presents a positive relation with cognitive functioning (Bennett et al. 2003; Mellor et al. 2016).

Education has an important function in neuropsychological processing, once that the greater the number of years of education, the better the performance of individuals in neuropsychological tasks (Parente et al. 2009). One research identified the variable years of education as an aggravator to cognitive decline in elderly individuals (Amieva et al. 2014), which means that the greater the number of years of education, the lower the risk of developing dementia. The protective effect of education may be explained by the constitution of CR, which delays the cognitive and functional appearance of neurodegenerative dysfunctions (Le Carret et al. 2003).

It was verified in this research that studying protects individuals from cognitive decline. In this sense, education appears as the component of most impact in CR (Silva et al. 2015). It is associated to greater cognitive aging and, in this manner, to a greater CR (Vance et al. 2012).

The variables gender (women and men), age, parents' education and reading activity were also related to CR (Bruno et al. 2014; López-Higes et al. 2013; Moral et al. 2013).

Other studies also highlighted that CR is influenced by sociodemographic characteristics (Aartsen et al. 2002; Oliveira et al. 2015). When dividing elderly individuals with low CR and cognitive decline, it was found a higher prevalence of women in both groups; 63,6% and 82,6% respectively (Moral et al. 2013). When approaching differences of gender in cognitive rehabilitation, men and women differ in form and size of some brain structures and in hormone dosage, as estrogen (Sohlberg and Mateer 2009) and it may also influence in cognitive functioning.

In relation to age, studies highlight that elderly individuals are more vulnerable to cerebral injuries (Sohlberg and Mateer 2009), which means that cognitive dysfunctions may be more recurrent over the years. A study performed in 1.068 elderly individuals identified that lower age and longer periods of study have a positive impact in cognition (Mellor et al. 2016). Another study also identified that factors as advanced age, female gender, lower education and presence of cognitive impairment are more related to Alzheimer's disease in noninstitutionalized elderly (Geerlings et al. 1999).

Reading activity was also associated to a better cognitive functioning and to a better quality of life for elderly individuals (Santos et al. 2014; Silva 2014). In other studies, reading activity was seen as a stimulating cognitive activity, for example, solving crosswords (Rami et al. 2011) and therefore considered a "cognitive leisure activity" (Lee and Chi 2015). Several studies highlight that leisure activities have a positive influence in "cognitive functioning of the elderly. It was identified that a greater number of leisure activity and years of study are protective factors in elderly cognition (Argimon and Stein 2005).

Another variable that may be positively related to cognition is professional activity (López-Higes et al. 2013; Marioni et al. 2012; Moral et al. 2013; Ribeiro et al. 2013). The practice of professional activities influences cognitive functioning in the sense of being an important variable of CR. The study of Sobral et al. (2014) which aimed to identify the predictor variables of CR from two evaluated groups (one composed of participants with Alzheimer's disease and the other composed of healthy individuals over 65 years old) found that both education and professional activity contributes to CR. A greater level of cognitive function in elderly individuals with larger periods of study and professional activity was also identified (Vemuri et al. 2014).

Professional activity may influence CR (both years of activity and years of retirement), considering that during retirement professional arrangements, productivity and responsibilities are decreased and stress is reduced. On the other hand, other activities related to family and community may increase (Wang and Shultz 2010). In this manner, a larger period of exercise of professional activities that demand reasoning and specific abilities contribute to CR, considering the necessity to utilize cognitive capacities.

Social engagement was associated to CR as the direct relation to cognitive functioning (Marioni et al. 2012). Silva and Yassuda (2013) state that individuals who are more involved in social activities may be healthier and present a better quality of life and cognitive functioning. Other studies also highlighted a positive relation between social engagement and a better cognitive performance in elderly (Figueiredo et al. 2013; Vemuri et al. 2014; Wang et al. 2002).

While evaluating lifestyle, cognitive decline and risk of dementia in 2.854 elderly individuals for 20 years, Marioni et al. (2015) observed an association among increase of social, physical and intellectual activities, a slower cognitive decline and a decrease of dementia incidence. Reading activities, education, professional activity and leisure, even when initiated in advanced age, improve cognitive functioning. Studies

demonstrate that the adequate stimulation in healthy elderly people improves cognitive functioning (Irigaray et al. 2012; Irigaray and Schneider 2008).

Humor characteristics as propensity to boredom, loneliness and depression were also identified as inversely associated to cognitive functioning (Conroy et al. 2010). A study found an association between depression, increase of risks of cognitive decline and Alzheimer's disease in the elderly (Geerlings et al. 2000). The study of Tzang et al. (2015) states the loneliness and depression are common characteristics in the process of aging. They have a direct impact in cognitive functioning of elderly individuals. It is found in scientific literature that social isolation is significantly associated to decrease in all measures of cognitive functioning.

Loneliness is associated to a poor evocation and late memory. It is observed that, even in individuals with higher education levels, social isolation causes impairment to cognitive functioning. Both loneliness and isolation are associated to poorer cognitive functioning in individuals of advanced age (Shankar et al. 2013). In this manner, through investigation and analysis of the six articles found, it was identified that the active model of CR is composed of the variables gender, age, education, parents' education, professional activity, reading activity, social engagement, humor (propensity to boredom, loneliness and depression) and cognitive functioning.

It is believed that CR is composed of many other variables that were not contemplated in this review, due to the existence of other activities that may be beneficial to the cognition of the elderly. Other activities, such as travelling, playing electronic games and practicing physical activity are components to be verified in new studies. Investigate other aspects as routine exams, psychological treatments, use of alcoholic beverage, the type of home and socioeconomic conditions. These suggested variables may influence the humor of the elderly individual and also influence CR.

A limitation of this study was to verify only the variables present in the active model of CR. However, according to the objectives of this review it was opted to verify only the first model, due to the contemplation of the second model, which consider biological, physical and neurological questions that are not in the scope of this review.

Compliance with Ethical Standards

Conflict of Interest The authors declare no conflict of interest.

Informed Consent As there is no person or personal data appearing in the article, there is no one from whom a permission should be obtained in order to publish personal data.

Ethical Treatment of Experimental Subjects (Human and Animal) This article does not contain any studies with human participants performed by any of the authors.

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