



# The relationship between cognitive reserve and personality traits: a pilot study on a healthy aging Italian sample

Barbara Colombo<sup>1</sup> · Giulia Piromalli<sup>2</sup> · Brittany Pins<sup>1</sup> · Catherine Taylor<sup>1</sup> · Rosa Angela Fabio<sup>2</sup>

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## Abstract

**Background** Exploring the role of different individual factors in affecting the cognitive reserve levels is crucial step for aging research. Several studies explored the relationship between personality traits and aging, but a specific focus on the cognitive reserve is missing.

**Aims** This study aimed at collecting more direct evidence about possible relationships between cognitive reserve and personality traits.

**Methods** A sample of 100 healthy aging participants was involved in the study. They completed the Big Five personality inventory and a test to assess the cognitive reserve.

**Results** Results returned a positive relationship between the personality traits and participants' cognitive reserve. The only factor that did not return a significant correlation was Emotional stability (which overlaps with Neuroticism).

**Discussion** This study provides additional evidence to the existing literature and also adds relevant information and a critical reading regarding the role of personality traits that has been neglected in the aging literature, Friendliness and Conscientiousness.

**Conclusion** The ability to measure and identify personality traits could be important in future research for developing interventions or activities that could target specific personality characteristics.

**Keywords** Cognitive reserve · Personality · Healthy aging · Big Five

## Introduction

Cognitive reserve (CR) can be understood on a basic level as a protective neural mechanism for coping with the effects of neural damage by either promoting the continuance of operation of a cognitive paradigm despite damage or providing a new paradigm, when the old one is too damaged to be used again [1]. Cognitive reserve is conceptually based on the more general reserve theory, which delineates a passive

model of reserve from an active model of reserve [1, 2]. The passive model focuses on the brain reserve capacity or threshold. It holds that brain reserve capacity varies per person, but among all people, functional deficits may occur when a threshold for neural damage is passed and the brain reserve is depleted. In contrast, the active model focuses on cognitive reserve. The inherent idea is that the brain actively uses pre-existing cognitive means or compensatory methods to complete functions that may have been affected by neural damage or age-related cognitive decline [2, 3]. The active model is used in the context of this study.

Stern [1] emphasizes the importance of exploring other factors that influence cognitive networks and age-related changes within the networks. For example, while education is a variable that researchers have been studying for several years, other variables such as personality traits could be a contributing factor with a potential influence on brain network activity in older individuals. A narrow focus on personality traits can benefit the theorists who research the increasing importance of cognitive reserve and other age-related

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✉ Barbara Colombo  
bcolumbo@champlain.edu

<sup>1</sup> Neuroscience Lab, Champlain College, 163 South Willard Street, 05401 Burlington, VT, USA

<sup>2</sup> Department of Clinical and Medical Medicine, University of Messina, Piazza Pugliatti 1, 98122 Messina, Italy

issues. Yet, if the relationship between personality and aging has been investigated from different perspectives, an investigation of direct relationship between the CR and personality is lacking, even of some information about this relationship can be derived from other studies. Researchers have been examining personality traits as a means of predicting changeability between individuals' cognitive aging processes. This route has been considered promising, because of the potential benefits that could be derived from being able to identify more elements that could help predicting the chances of cognitive decline [4].

Personality traits are defined as differences in cognitive and affective experiences that have implications on behavior, and this relationship is believed to be effective and relevant for the aging population [4]. The personality traits specifically considered to be the most widespread and elemental in adults (regardless of age and culture) are the Big Five personality traits: Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness [4]. These traits are furthermore derived from the five factor model (FFM) [5]. The FFM has traditionally been made up of the following five factors as identified by Goldberg [6]: (I) Surgency (or Extraversion or Energy); (II) Agreeableness (or Friendliness); (III) Conscientiousness (or Dependability); (IV) Emotional stability (vs. Neuroticism); (V) Culture (or Openness to Experience). Alternatively, factor V has been interpreted as Intellect [7] and as Openness [8].

The ever-growing empirical interest in the Big Five personality traits as they apply to cognitive ability of aging population is reflected and discussed in a recent review by Curtis et al. [4]. The studies included in the review focused on non-clinical aging populations. Studies on clinical population (i.e., different kinds of dementias) are discussed in a recent meta-analysis [9]. From these analyses, we can derive that even if some consistent relationships are reported, several contradicting results also emerge, and for these reasons the authors stress the need for more research and analyses to clarify these inconsistencies. Our study addresses some of these inconsistencies by adopting the theoretical framework of the cognitive reserve model to get a more unified view of the relationships between specific personality traits and aging, focusing on healthy aging population. These two aspects together could help identifying early markers for cognitive decline that could be addressed early on, increasing the rate of healthy aging. Previous studies report interesting, if, as mentioned, conflicting results that were used as a guide for defining the hypothesis of our own study.

The first interesting information concerns the role of two almost opposite traits: Neuroticism (linked to higher levels and less effective emotional regulation of negative emotions) and Openness (linked to higher levels of creativity and interest for new experiences). If Openness sounds very closely related to the behaviors that are supposed to

improve the cognitive reserve [10, 11], the link between Neuroticism and aging is less direct. Individuals with high level of neuroticism tend to report higher levels of anxiety, which have been reported to lead to poorer neuroplasticity in the aged individual [12]. A few studies also reported a positive correlation between high levels of Neuroticism and lower fluid reasoning and lower general cognitive capability, aspects that could lead to a significant global cognitive decline and higher chance of developing Alzheimer's [13, 14]. These results have not been confirmed by all the studies who investigated this relationship [4]. The discrepancies could be explained by the fact that if it is true that higher levels of Neuroticism could potentially predict cognitive decline, it could also be true that higher levels of cognitive decline could lead to higher levels of anxiety, and therefore increase overall Neuroticism levels.

On the other hand, as briefly mentioned above, Openness has been tied to higher levels of fluid reasoning and general cognitive capability, aspects traditionally also were linked to higher cognitive reserve [2]. Individuals with high Openness are more inclined to search for new, stimulating ideas, activities, and experiences. Some of these novel stimuli may help individuals to strengthen their general cognitive abilities and memory capabilities, which in turn could promote healthy aging [4].

Extraversion (Energy) is lacking in substantive links in research to healthy aging. It is worth noting that those who are more social later in life tend to score higher on measures of Extraversion [15]. Maintaining strong social networks late in life is a protective factor for maintaining a healthy cognitive reserve [11] by promoting neuroplasticity [12], limiting the decline of cognitive performance and reducing the risk of developing dementia [16]. Extraversion has also been linked with functional impulsivity, a trait which allows a person to think quickly in situations where fast thinking will be beneficial [17]. Functional impulsivity can be advantageous in cognitive tasking and social situations in which time is limited [17].

There is an absence of clear links between Conscientiousness and cognitive reserve in the existing literature. However, some data [14] suggests that Conscientiousness can be linked to a slower, more gradual age-related decline in cognitive ability. Furthermore, a recent study [18] suggests that individuals with a low score on Conscientiousness are at greater risk for some form of non-dementia cognitive impairment as well as incident dementia. Low levels of conscientiousness appeared to correlate with risk of conversion from cognitive impairment not dementia (CIND) to dementia for those who began the study with CIND. High levels of conscientiousness could then be thought to result in a lower conversion risk for those with CIND [19].

Agreeableness (Friendliness) cannot be substantially linked to cognitive ability in older adults. If many

researchers have noted that no evidence has determined a link between cognitive ability and agreeableness [4], a small group of studies has addressed the need for further research in this area. A recent meta-analysis by D'Iorio et al. [20] explored a small number of studies that investigated the Big Five personality traits in individuals with Alzheimer's disease and healthy aging participants. Higher levels of Agreeableness were associated with lower risk of Alzheimer's disease. Along these lines, Hill et al. [21] designed a study to determine personality traits that enable individuals at high risk for cognitive decline to respond better to treatment than others. The study suggested that individuals with higher scores of agreeableness benefited more from the intervention than those with lower scores. The authors suggest that this is due in part to an individual's eagerness to help others, which can lead participants to participate more fully in the intervention and thereby to realize greater benefit.

Starting from the evidence discussed above, our study aimed at collecting direct evidence about possible relationships between cognitive reserve and personality traits. Moreover, data derived from studies investigating the relationship between (healthy) aging and personality traits often report conflicting results and tend to exclude some traits: the present study aims at exploring the main five personality traits, and also specific facets of each of them. This fine grain analysis should allow us to investigate the possibility that when conflicting results are reported this can be because the relationship between the CR and the specific trait could be significant only for one particular facet of that trait.

It is worth noting that cognitive reserve is a challenging concept to measure due to its less tangible, hypothetical nature [22]. Proxy measures are typically employed in place of direct measures, which would arguably be impossible to create and execute. Furthermore, neuronal pathological measures would not be easy for the average researcher to conduct [23]. The most commonly used proxy measures used in the literature refer to educational level and literacy, occupational status, and engagement in cognitively stimulating leisure activities [11, 24–28]. Efforts have been made to develop tools that could assess all these aspects, be developing ad hoc questionnaires [29]. Yet, these instruments seem to be lacking the elements to assess cognitive function in some different domains that meta-analytic evidence [30] as well as experimental studies [31] report as possible indexes of the CR. For this reason, in this study, we decided to use the CoRe-T [10] that (as detailed in the methods section) aims at overcoming the abovementioned limitation by adding a section on fluidity of thoughts to the commonly used proxies discussed above.

Starting from the assumption, discussed above, that personality plays a large part in the actions one may choose to partake in during their lifetime, we can also assume that understandings of each Big Five trait could potentially be

used to predict how an individual may act, and furthermore how that will reflect on their later-life cognitive reserve. This would allow not only, as mentioned in the previous paragraphs, help clarifying some of the conflicting results reported in the literature, but also allow to plan early interventions to increase the CR of individuals who, because of their personality traits, would be less likely to develop a higher one and would hence be at higher risk for incidence of cognitive decline or dementia. Being able to start early intervention to increase the CR is extremely important because, as emerged from the results of a longitudinal study [32], the CR appears to be a reflection of how persistent an individual is with exercising different cognitive skills early on, rather than a set measure of individual differential rates of age-associated cognitive decline.

## Methods

### Participants

Before starting data collection, we run an a priori power analysis using G\*Power to compute the required sample size for our study. We used as parameters for our bivariate normal model a two tails model, an  $\alpha$  error probability of 0.05, we estimate the correlation  $\rho$   $H1 = 0.3$  (based on the results previously reported in the existing literature) and asked for a Power ( $1 - \beta$  err prob.) of 0.80. The total sample size to meet these requirements was estimated to be equal to 84.

One hundred healthy participants (age between 50 and 90, mean 62.77, SD = 11.0), balanced by gender ( $F = 54$ ), joined the study. Considering the years of education, they had a range of 20 (minimum = 3 yrs.; maximum 23 yrs.), with a mean of 12.6 (SD = 5.03) years, and a median of 13 years.

Participants with a diagnosis of dementia or other age-related neurodegenerative disorders have been excluded. We screened the interested participants by asking them about any diagnosis, which medication they were currently taking, and details about recent doctors' appointments. Participants who reported symptoms or diagnosis linked to dementia or other age-related disorders were excluded. Participants living in assisted living communities have also been excluded to guarantee higher homogeneity within the sample. All participants were living autonomously and most of them were sharing their house with one or more care partners (wife/husband or siblings).

### Materials

Big Five Questionnaire (BFQ)—The 132-items Italian version of the Big Five Questionnaire [33] was used in this study to assess personality traits. The questionnaire assesses

five dimensions inspired by the five factors model, each of them presenting specific facets.

- Openness to Experience [5], which includes “Openness to Culture” (the broadness or narrowness of one’s own cultural interests) and “Openness to Experiences”, i.e., openness to novelty, tolerance of different values, interest toward different people, habits, and life styles.
- Conscientiousness organized into “Scrupulousness” (i.e., dependability, orderliness, and precision,) and “Perseverance”: the capability of fulfilling one’s own tasks and commitments. This dimension takes into consideration of impulse control in both its proactive and inhibitory aspects [34].
- Energy overlaps with Extraversion [8]. The label “Energy” was chosen for the Italian version given the more specific meanings that in the Italian context are associated with the word “Extraversion” (always used as a synonym of Sociability). This dimension includes “Dynamism” (expansiveness and enthusiasm) and “Dominance”, which refers to assertiveness and confidence.
- Friendliness overlaps with Agreeableness [8]. It includes the dimensions of “Cooperativeness/Empathy”, which refers to concern and sensitiveness toward others and their needs, and “Politeness” (i.e., kindness, civility, docility, and trust).
- Emotional stability can be conceived as “negative affectivity” and it is part of the same spectrum as Neuroticism [8]. It includes “Emotion Control” (i.e., the capacity to cope adequately with one’s own anxiety and emotionality) and “Impulse Control”: the ability of controlling irritation, discontent, and anger.

This version of the Big Five has been validated on five different Italian samples, and its psychometric properties proved it to be reliable: Cronbach’s alpha between .60 and .90; Pearson’s  $r$  for test–retest between .68 and .87 [33].

CoRe-T—This instrument has been created to assess the cognitive reserve in a comprehensive way [10]. It has two main sections (self-report and fluidity of thoughts tasks). Self-report data include information about education level (years of completed education, including vocational training), type and frequency of leisure activities (both frequency of performing, teach specific selected activity, and numbers of years they have been practicing it are recorded), and occupation history (type of occupations and the number of years they have been working in each position). Two tasks were used to assess fluidity of thought: the “Acronyms” task, where participants are given 5 min to list all the terms that can fit into the three given acronyms (the terms had to make sense together), and the “Alternative use task”, where participants, in 5 min, are asked to list as many different, interesting, or unusual usages for an empty plastic bottle as they can.

For each task, a fluidity score (numbers of valid answers) and an originality score (where each answer was coded as original (1) or not original (0) and a cumulative score was computed by adding the number of original answers) were computed. Criteria for scoring were derived from the guidelines derived from the Torrance Test of Creative Thinking [35], from which these tasks were inspired. Two researchers coded all the answers independently. Cases of disagreement in scoring responses to the creative tasks were discussed and resolved case by case by the two researchers.

Cronbach’s alpha for the CoRe-T was 0.78.

## Procedure

Participants have been selected using a randomized block design based on age.

Before starting the data collection, the aims of the research have been explained and participants have also been asked to sign a consent form. Each individual test was introduced and explained to each individual by one of the researchers. Researchers were also available during the administration of the tests to answer any question or clarify any statements that participants might find too complicated.

After all the three tests have been conducted, and the answers recorded, participants were offered the opportunity to ask any additional question. Researchers reminded them that all the data were completely anonymous and thanked for their participation.

## Results

Descriptive statistics (mean scores and standard deviations) regarding the CoRe-T total score and the Big Five scores for each scale and subscale are reported in Table 1.

As a first step, we computed a total score for the self-report section of the Core-T (education level, leisure activities, and occupation history) and we checked for possible gender differences. No significant difference emerged ( $t_{98} = -0.60$ ,  $p = 0.55$ ) between females ( $M = 43.70$ ,  $SD = 11.01$ ) and males ( $M = 42.46$ ,  $SD = 9.66$ ). For this reason, gender differences have not been taken into consideration in the subsequent analyses.

## Relationship between the cognitive reserve and personality traits

Using two cumulative scores for the CoRe-T (one that includes the fluidity of thought section and one that includes only the self-report section), we run a series of correlations among the CoRe-T and the personality traits.

**Table 1** Mean scores and standard deviations for the CoRe-T and Big Five scores

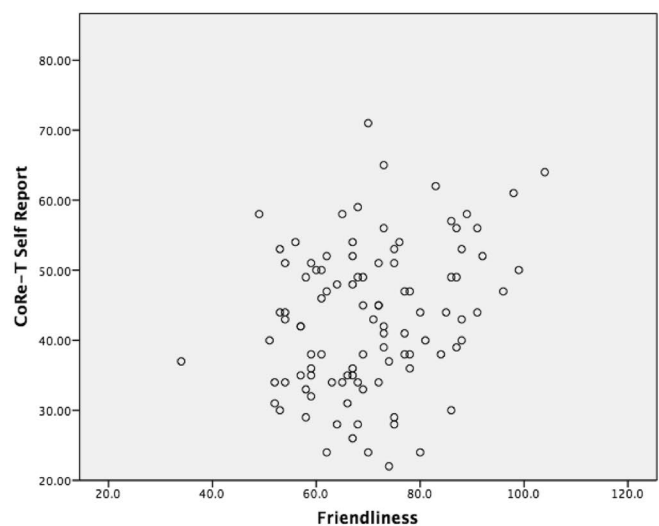
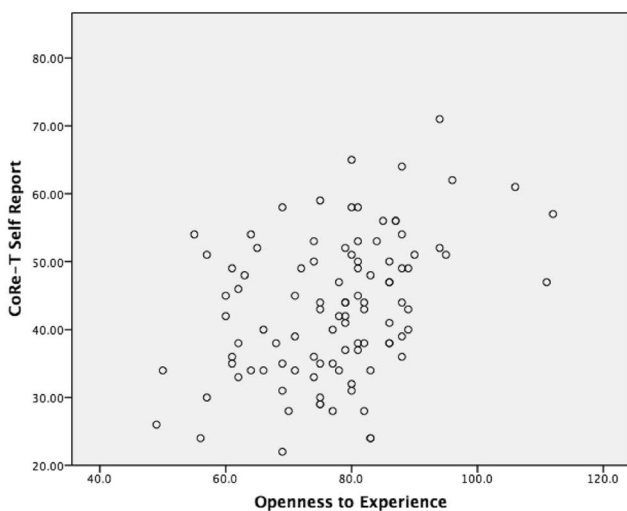
	Mean	Std. deviation
<i>CoRe-T total score</i>	43.13	10.38
<i>Openness to experience</i>	77.39	11.80
Openness to culture	39.86	7.35
Openness to experiences	37.62	6.85
<i>Conscientiousness</i>	83.63	14.12
Scrupulousness	43.38	30.68
Perseverance	43.56	9.63
<i>Energy</i>	74.73	13.22
Dynamism	39.40	7.26
Dominance	35.33	8.45
<i>Friendliness</i>	70.30	12.89
Cooperativeness/empathy	36.60	7.14
Politeness	33.70	7.21
<i>Emotional stability</i>	71.69	16.07
Emotion control	37.78	8.93
Impulse control	33.92	8.86

**Table 2** Correlation coefficients between CoRe-T scores and the main five personality traits

	CoRe-T total	CoRe-T self-report
Openness to experience	$r=0.23; p=0.02$	$r=0.39; p<0.001$
Conscientiousness	$r=0.04; p=0.70$	$r=0.23; p=0.02$
Energy	$r=0.22; p=0.03$	$r=0.22; p=0.02$
Friendliness	$r=0.20; p=0.04$	$r=0.27; p=0.01$
Emotional stability	$r=0.06; p=0.53$	$r=0.05; p=0.63$

Number of participants = 100

Significant correlations are highlighted in bold



**Fig. 1** Scatter-plots highlighting the correlation between Trait “Openness to Experience” and “Friendliness” and the CoRe-T self-report score

We started by exploring relationship between the Core-T scores and the five major traits. The values of  $r$  and significance levels are reported in Table 2.

When considering only the self-report score from the CoRe-T, all the factors other than Emotional stability correlate positively and significantly with the cognitive reserve levels. The two factors that correlate more strongly are the Openness to Experience and Friendliness. When including flexibility of thought to the CoRe-T score, Openness to Experience and Energy are the strongest correlations, while Conscientiousness does not correlate significantly.

A scatter-plot summarizes the results (Fig. 1), representing the strongest correlations reported in Fig. 1.

To follow up on this first analysis, we run correlations considering all the dimensions for each of the main traits. Results are reported in Table 3.

Focusing on the Openness to Experience trait, both dimensions correlate significantly with the self-report part of the CoRe-T, but when considering also flexibility of thought, only Openness to Experiences plays a significant role. Considering Conscientiousness, it is the dimension of Perseverance to correlate significantly with CoRe-T self-report total score. When the trait Energy is considered, it is the Dynamism dimension that plays a significant role. Focusing on Friendliness, both Cooperativeness/Empathy and Politeness correlate significantly with the self-report total score of the CoRe-T, while it is only Politeness to correlate significantly, when flexibility of thought is added.

A scatter-plot summarizes the results (Fig. 2), representing the strongest correlations reported in Fig. 2.

**Table 3** Correlation coefficients between CoRe-T scores and the personality dimensions

	CoRe-T total	CoRe-T self-report
<i>Openness to experience</i>		
Openness to culture	$r=0.15; p=0.14$	$r=0.36; p < 0.001$
Openness to experiences	$r=0.21; p = 0.03$	$r=0.26; p = 0.01$
<i>Conscientiousness</i>		
Scrupulousness	$r=0.04; p=0.66$	$r=0.04; p=0.67$
Perseverance	$r=0.08; p=0.43$	$r=0.32; p = 0.001$
<i>Energy</i>		
Dynamism	$r=0.19; p = 0.05$	$r=0.26; p = 0.01$
Dominance	$r=0.18; p = 0.07$	$r=0.12; p=0.22$
<i>Friendliness</i>		
Cooperativeness/empathy	$r=0.213; p=0.18$	$r=.23; p = 0.02$
Politeness	$r=0.23; p = 0.02$	$r=.26; p = 0.01$
<i>Emotional stability</i>		
Emotion control	$r=0.12; p=0.21$	$r=0.15; p=0.15$
Impulse control	$r=-0.02; p=.86$	$r=-0.07; p=0.51$

Number of participants = 100

Significant correlations are highlighted in bold

### The role of personality traits in predicting the cognitive reserve

To further explore the role of different personality traits in influencing the CR, we run a series of linear regression analyses, using the CoRe-T score as dependent variable and the Big Five scores as predictors. To control the effect of age, we also added age as a predictor to our model. Results are reported in Table 4.

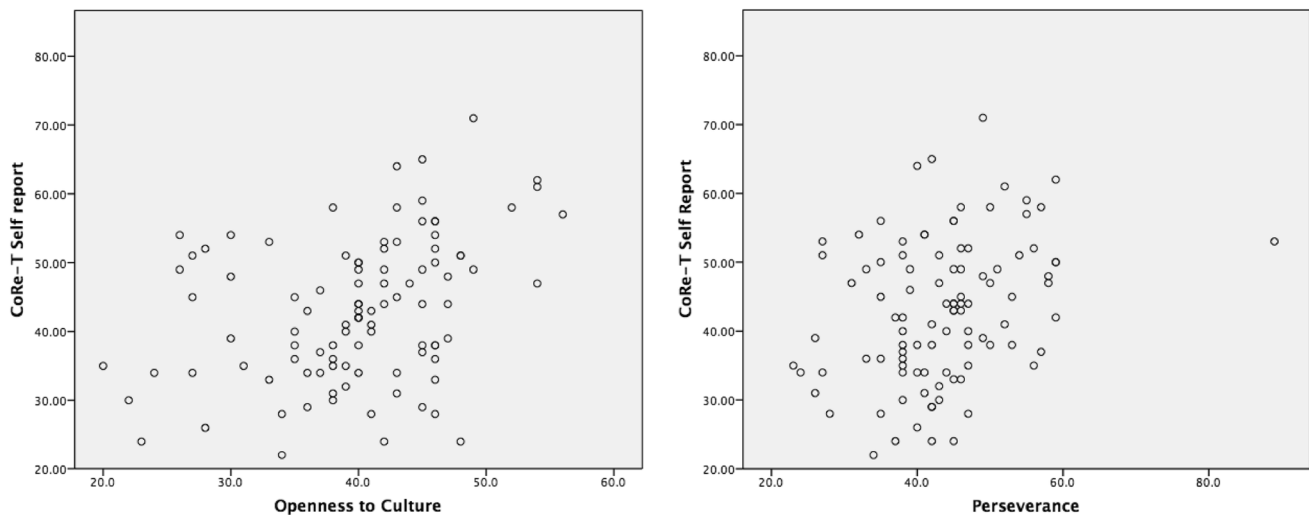
As expected, age has a negative influence on the CR, as measured by the CoRe-T.

Considering the Big Five model, Openness to Experience was the only main factor to significantly influence the CR. People who score higher in this dimension could be expected to have a higher CR.

Moving to the Big Five subscales, some other significant factors emerged. Openness to culture seems to be the critical factor in influencing the increase of the CR of these individuals who score higher in the Openness to Experience scale. Other personality traits that appear to promote and higher CR are perseverance, dynamism, politeness, and emotional control.

### Conclusions

The main aim of this study was collecting more direct evidence about possible relationships between cognitive reserve and personality traits, also exploring the influence of specific sub-aspects linked to the general Big Five personality traits, using a comprehensive tool to assess the cognitive reserve of an Italian healthy aging population. Using a CR test that assesses flexibility of thought as well as the more traditionally used proxies of the CR, we were hoping to overcome some of the limitation of other methods of assessment of the CR, which could underestimate the role of elements to assess cognitive function in some different domains that go beyond those assessed by traditional proxies like level of education, occupation, and type of leisure activities [30, 31]. Using this more comprehensive tool could also, at least partially, help measure the CR as a reflection of how persistent an individual has been with exercising different cognitive skills during the lifespan. This perspective has been reported to be another promising approach to assess the CR [32].



**Fig. 2** Scatter-plots highlighting the correlation between Trait “Openness to Culture” and “Perseverance” and the CoRe-T self-report score

**Table 4** Linear regression models considering the effects of personality traits and age on the cognitive reserve

	b	SEb	$\beta$
<i>Big Five personality traits</i>			
Constant	30.14	11.45	
Age	-0.29	0.09	-0.31***
Openness to experience	0.18	0.09	0.21*
Conscientiousness	0.13	0.07	0.17
Energy	-0.02	0.08	0.02
Friendliness	0.14	0.08	0.18
Emotional stability	-0.05	0.07	-0.07
$R^2 = 0.29, p < 0.001$			
* $p < 0.05$ , *** $p < 0.001$			
<i>Openness to experience-subcales</i>			
Constant	42.12	9.35	
Age	-0.30	0.09	-0.32***
Openness to culture	0.39	0.14	0.27**
Openness to experiences	-0.12	0.15	-0.08
$R^2 = 0.24, p < 0.001$			
** $p < 0.01$ , *** $p < 0.001$			
<i>Conscientiousness-subcales</i>			
Constant	50.98	7.18	
Age	-0.35	0.08	-0.37***
Scrupulousness	0.02	0.03	0.06
Perseverance	0.30	0.09	0.27**
$R^2 = 0.22, p < 0.001$			
** $p < 0.01$ ; *** $p < 0.001$			
<i>Energy-subcales</i>			
Constant	53.79	9.10	
Age	-0.33	0.09	-0.35***
Dynamism	0.26	0.15	0.18*
Dominance	-0.01	0.12	-0.01
$R^2 = 0.18, p < 0.001$			
* $p < 0.05$ ; *** $p < 0.001$			
<i>Friendliness-subcales</i>			
Constant	52.58	8.07	
Age	-0.35	0.09	-0.37**
Cooperativeness/empathy	0.05	0.17	0.03
Politeness	0.32	0.16	0.22*
$R^2 = 0.21, p < 0.001$			
* $p < 0.05$ , ** $p < 0.01$			
<i>Emotional stability-subcales</i>			
Constant	61.21	7.27	
Age	-0.33	0.09	-0.35**
Emotional control	0.26	0.14	0.22*
Impulse control	-21	0.14	0.18
$R^2 = 0.18, p < 0.001$			
* $p < 0.05$ , ** $p < 0.01$			

The first main result is that we were able not only to find a positive relationship between the personality traits and the CR, but also to identify specific personality traits that could positively influence the CR. The only factor that did

not return a significant correlation was Emotional stability (Neuroticism). This result is not surprising, given the fact that, as mentioned in the introduction, studies that explored the relationship between Neuroticism and healthy aging reported conflicting results [4]. If our study supports the group of studies that report no link between healthy aging and Neuroticism, more research is needed to further explore the possible relationship between Emotional stability and CR. A possible reason of the lack of consensus is that while most studies assess healthy aging focusing on cognitive factors, Emotional stability could have a more direct effect on emotion regulation, and hence only an indirect effect on the CR. This reading is supported by a recent study [36], which explores the link among stress, cognitive aging, physiology, and emotions. The authors hypothesize that stress-related physiological dysregulation (more common in individuals who score high on neuroticism) can result in accelerated cognitive decline over time. These results support the idea that relationship between Neuroticism and CR levels could be less direct and be mediated by exposure to stressors combined by the tendency of engaging in stress-related unconstructive repetitive thought. This is also partially confirmed by the fact that if emotional stability per se did not influence the CR significantly, the emotional control sub-factor did. This interesting finding can be related and at least partially explained, also considering the specific neurobiology of emotion in aging population. If it is true that emotional functioning is generally well preserved, while aging [37], changes in the overall functioning of different brain systems may lead to changes in the coping strategies that older adults use, when dealing with difficult emotional situations [37, 38]. A possible reading of our data is that these differences could be due to personality differences in emotional control and this could potentially be the key factor that affects the levels of CR.

The fact that Openness and Friendliness (Agreeableness) return a strong positive correlation with the CR levels and also Openness in particular had a direct positive influence in increasing the levels of the CR is not surprising, given the importance, in terms of cognitive reserve, of having social connections and a support system [11]. Socializing is important for brain health and having larger numbers of people in one's social network or higher quality of relationships can have a positive effect on one's cognitive functioning [39]. One reason social interaction has such an effect on one's cognitive abilities could be in part due to the social implications that can have on stress. While stress is a negative influence on social interactions and cognitive reserve, many social interactions involve intense thought processing that can stimulate and activate different parts of the brain [40].

Our results also highlighted that Politeness, which is an aspect of Friendliness, was most correlated with cognitive reserve levels, when flexibility of thought was added. This

ties in as well with the significances found between performance on the CoRe-T and high levels of Energy, which implies sociability in terms of Dynamism and Dominance. Politeness and Dynamism (both also resulted to significantly predict the levels of CR according to our regression model) could be considered helpful social tools for creating and maintaining positive social connections. Further research should be conducted to investigate why Cooperativeness/Empathy did not significantly correlate with CoRe-T total scores and only CoRe-T self report scores.

Conscientiousness is another factor that has not been extensively studied in the literature. Within our sample, high levels of Conscientiousness only correlated significantly with high scores on the CoRe-T self report. The failure to find a significant correlation between Conscientiousness and the CoRe-T after the flexibility of thought portion has been added could be explained by the inhibitory effects of high levels of Conscientiousness on the ability to be impulsive and spontaneous, a line of reading that is confirmed by studies that explored the relationship between Conscientiousness and creativity in younger populations [41, 42]. Yet, other studies contradict this result, highlighting a positive relationship between these variables [43, 44]. It is possible that the relationship between Conscientiousness and creativity is task specific or, as some studies suggest, mediated by self-concept of creative self-efficacy [45, 46]. Future research should aim to explore more in depth the relationship between Conscientiousness and some aspects of flexibility of thought in aging population, taking self-efficacy into consideration. It is also worth noticing that our regression model highlighted how perseverance (a sub-factor of Conscientiousness) could significantly predict the levels of CR. Considering the effect of Conscientiousness on health, it has been reported that this personality traits could help neutralizing stressors, leading to the promotion of health behaviors and the minimization of risk behaviors [47]. Yet, meta-analyses reveal that these associations are moderated by factors that are not well understood [48, 49] and researchers suggested a more complicated model where the role of other personality traits is taken into account as well as the way people age over several decades [47]. This model is quite interesting with reference to our data: it looks like it could explain the correlation between Conscientiousness and the CR and also how over time, this trait could help promoting healthy behaviors and lessens stress factors, which in turn would promote higher levels of CR.

As expected by the findings that link Openness to Experience with cognitive abilities and fluid reasoning, there was a strong positive correlation found in this study between high scores on Openness to Experience and high scores on the CoRe-T self report as well as the CoRe-T total. This strong correlation can be explained by the propensity of those who score higher on Openness to “think outside the box”.

Furthermore, those who score higher on Openness to Experience are inclined to subject themselves more frequently to novel experiences and ideas [4].

Overall, results from our study aligned with the consensus in existing research that personality traits do influence healthy aging, and, more specifically, the cognitive reserve. The ability to measure and identify an individual’s personality traits could be important in future research for developing interventions or activities that could target specific personality characteristics [21], improving the success rate of interventions for dementia.

Our study, apart from providing additional evidence to the existing literature, also added relevant information and a critical reading regarding the role of personality traits that have been somehow neglected in the literature, i.e., Friendliness (Agreeableness) and Conscientiousness.

Future research should include a larger sample size of more varied participants, including those with dementia and cognitive impairment not dementia to better understand influences that personality traits may exert on unique individuals’ cognitive reserve. Exploring the moderating effects of personality traits on the CR could also be a promising way to have a better understanding of this complex relationship.

## Compliance with ethical standards

**Conflict of interest** The authors declare no conflict of interest.

**Statement of human and animal rights** All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and national research committees (University of Messina and Champlain College–IRB000128) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

**Informed consent** All participants were asked to sign a consent form to be included in the study. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committees (University of Messina and Champlain College–IRB000128) and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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