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Research Article

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Does Brain Sweat Pay Off?: The Association between the Need for Cognition and Cognitive Function among the American Elderly

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Abstract

Background: The global incidence of impaired cognition increases with the overall aging of the population. Regarding prophylactic measures, it is unclear whether engaging in cognitively-stimulating activities can decrease the risk of cognitive impairment.

Objective: To determine the association between Need for Cognition and cognitive ability within a representative mirroring sample of the elderly population in the United States.

Methods: We evaluated the association between Need for Cognition (measured through cognitive effort and enjoyment scores) as a predictor and neurocognitive scores (number series, concept formation, calculations, word attack, picture vocabulary, auditory working memory and similarities) as outcomes using the CogUSA dataset.

Results: A total of 1,174 participants of at least 64 years of age were part of this analysis. Participants attending college (49.4%) presented higher cognitive effort and enjoyment scores. The findings demonstrate a two-factor structure, the first related to neurocognitive tests and the second related to need for cognition, with good factor loadings.

Conclusion: Need for Cognition and neurocognitive ability is strongly correlated and could perhaps be constructed as a single factor. Future research should focus on assessing the relationship between the Need for Cognition and cognitive function in the context of a multitude of other factors, thus determining the contribution of individual factors under different circumstances.

Keywords: Cognition; Aging; Cognitive aging

Introduction

Aging is associated with a decline in basic cognitive functioning, including deficits in attention and episodic memory [1]. The incidence of individuals with declined cognition has increased with the global increase in the aging population that accompanies increased life expectancy [2]. In an attempt to prevent cognitive impairment, some studies have evaluated whether being involved with cognitively-stimulating activities can decrease the risk of cognitive decline [3,4]. In the literature, one of the metrics for engaging with cognitively-stimulating activities is the Need for Cognition, defined as “the tendency for an individual to engage in and enjoy thinking” [5]. Other activities commonly associated with people with high Need for Cognition levels might include searching, acquiring, and reflecting about information, all of which correspond to activities that could potentially decrease the risk of subsequent cognitive deficits. Despite this potential association, to our knowledge, these studies evaluated the association between need for cognition and cognitive ability only within local samples that do not mirror representative of the entire United States population [6,7].

When it comes to the study of the association between the need for cognition and cognitive ability, some studies found an association while investigating both small and large non-representative samples. For example, higher levels of Need for Cognition have been found to lead toward increased cognitive ability in up to two years [6]. Other studies found that self-reported engagement in cognitive leisure activities was associated with a slow onset of memory impairment among dementia patients [8]. Cognitive training programs are associated with improved targeted cognitive abilities among the aging population in the United States with relatively long-lasting beneficial effects [9,10]. Similar long-term outcomes have been reported in large trials for healthy older participants in the UK [11] and at-risk elderly persons of the Finnish population [12]. However, these findings are not without controversy. For example, when evaluating the association between active engagement and cognitive performance in the elderly, a previous study found that participation in leisure activities was not associated with a decreased regression of cognitive performance [13]. This controversy might partially be explained since all of the studies mentioned above have focused on local samples rather than samples representing a given population. Sample representativeness is not necessarily connected to sample size, but instead to the methods used during the selection of individual participants so that the final sample can represent the target population [14]. To our knowledge, no previous evaluations have been conducted to assess the association between cognitive function and Need for Cognition using other than local samples.

In the face of this gap in the literature, the objective of this study was to evaluate the association between Need for Cognition and cognitive

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ability within a sample that mirrors the primary Health and Retirement Study sample, namely the CogUSA database [15].

Materials and Methods

This study aimed at investigating the relationship between the Need for Cognition and cognitive ability among the elderly using the CogUSA database. The sample mirrors the Health and Retirement Study that surveys a nationally-representative sample of over 37,000 individuals in the United States [16]. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) Statement was used to guide reporting and modeling methods [17].

Ethics

The Institutional Review Board at the University of Basilicata, Potenza, Italy approved the study.

Settings

We made use of the Cognition and Aging in the USA (CogUSA) study database [15]. The CogUSA is an American longitudinal study which emphasizes age-related cognitive changes for individuals of at least 51 years of age, as well as the impact of these changes on health and economic aspects. The CogUSA sample mirrors the leading Health and Retirement Study sample [16], which was representative of the United States population. Data collection for the CogUSA database was performed in three waves. The first wave was a telephone interview, lasting about 40 min and conducted to obtain demographic information and short neurocognitive tests. Within a week from completing the first wave, the second wave was conducted as a face-to-face interview to assess cognition through an extensive testing battery [18-20], the Need for Cognition Scale [5] and the Big Five Personality Traits tests [21]. Between one and 24 months later, the third wave was performed as a replication of the first wave. Our study focused on cognitive tests performed during the first and second waves, and can, therefore, be considered as a cross-sectional study given that the difference in time between the two was, on average, one week. Data were collected from May of 2007 to September of 2009 [15].

Participants

The study sample included participants born in 1956 or earlier, using a two-stage random digit-sampling method. A total of 28 primary sample units were identified from a Genesys database (http://www.m-s-g.com/web/genesys/index.aspx) across the United States. Weights were first constructed using the probability of selection into the sample from the set of 28 primary sampling units. Samples were weighted in several steps. The second step consisted of comparing samples of the first wave to the Health Retirement Survey 2004 sample as both groups had similar participants. Education, gender and rural/urban status were factors used to perform post-stratification to the Health Retirement Survey 2004. Participants who did not undergo a complete cognitive interview were excluded from our sample, as were individuals participating in both the CogUSA and the Health and Retirement Survey.

Variables

Our primary outcome measures involved a series of cognitive abilities tests measuring constructs that have been previously demonstrated to be involved with activities related to the Need for Cognition [22-24]: (1) Similarities - participants describe how similar two words or concepts are, measuring verbal concept formation and reasoning; (2) Number series - respondent looks at a number series with a missing number, determining the pattern and identifies the missing number to complete a numerical sequence. It measures quantitative reasoning; (3) Picture vocabulary - respondents identify familiar and unfamiliar pictured objects, measuring aspects of lexical knowledge; (4) Auditory working memory - respondent listens to mixed series of words and digits while attempting to reorder them by words and numbers in order. It measures the short-term working memory; (5) Concept formation - participants identify rule application and frequent rule-switching after being exposed to concepts, measuring inductive reasoning; (6) Calculation - measures participants' ability to perform mathematical calculations including addition, subtraction, multiplication and division and (7) Word attack - participants read aloud non-words or low-frequency words in English, and it assesses their skill in using phonic and structural analysis to pronounce unfamiliar word [15,19]. These tests were extensively validated and tested for reliability concerning their ability to measure neurocognitive outcomes [25-28]. The higher scores indicate better performance. Given that these outcomes overlap, duplicates were removed by the original survey researchers [15].

Predicting variables

Predicting variables included those associated with Need for Cognition, namely Cognitive Enjoyment, and Cognitive Effort scores measured using a validated 18-item short form. The score is calculated using a 5-point Likert scale ranging from strongly disagree to strongly agree [5,15].

Potential confounding variables

We selected potential confounders using a combination of clinical judgment and evidence from the literature, as this combination of criteria has been demonstrated to perform better than the isolated selection of isolated clinical and evidence-based criteria [29]. Specifically, we selected educational level, birth year, race, gender and marital status, as these variables have been previously associated with different cognitive levels [30,31].

Data analysis

We started our analysis with a visual exploration to evaluate the frequency, percentage and near-zero variance for distribution for numeric variables (cognitive abilities tests and need for cognition variables) and missing values and patterns across all variables [32]. Near zero variance was attained when a categorical variable presented a small percentage of a given category and was addressed by combining different variable categorizations. Missing values were handled through imputation algorithms followed by sensitivity analyses to verify whether our results were stable with and without imputation [33].

We used correlation matrices and plots as exploratory analysis tools to better understand the correlation between Need for Cognition variables and cognitive abilities tests: Number series, concept formation, calculations, word attack, picture vocabulary, auditory working memory and similarities. Since items were numeric, we used Pearson or Polychoric correlation tests as appropriate. We also conducted a series of exploratory factor analyses using oblique and orthogonal rotations to explore different factorial solutions underlying the data, using maximum likelihood as the extraction method. A heuristic for the selection of factor solutions included scree plots, solutions that were theoretically justifiable, and solutions where items loaded with values above 0.30 on a single factor while all other loadings were below that level.

We then used a series of confirmatory bi-factor models evaluating the relationship between Need for Cognition and cognitive abilities. All models were theoretically justified. Fit statistics for confirmatory factor analyses included fit function value, χ^2 value based on the fit function, and degrees of freedom (df). During the process of modeling, the justification for modifications was based on a combination of Lagrange and Wald tests for adding and dropping paths, respectively, as well as for the requirement of a plausible theoretical justification. We also report estimated parameters squared multiple correlation/variance accounted for each model and standardized as well as unstandardized estimates. We did not account for survey weights, strata and population survey units as our intent was not to draw population inferences.

Finally, structural equation models measured the association among the Need for Cognition and cognitive ability constructs. Need for Cognition was evaluated through scores for cognitive enjoyment and cognitive effort. Cognitive ability was evaluated through scores for number series, concept formation, calculations, word attack, picture vocabulary, auditory working memory and similarities. All models were theoretically justified, using the same set of fit statistics previously reported for Confirmatory Factor Analyses.

Results

A total of 1,174 participants of at least 64 years of age were part of this analysis. The majority of participants were white Caucasian (91.1%), married (65.3%), with females representing over half (54.4%) of the sample's participants. Participants attending college (49.4%) presented higher cognitive effort and enjoyment scores than those not attending college when stratifying our sample by median values for cognitive enjoyment (Table 1) and cognitive effort scores (Table 2).

Table 3 evaluates the underlying factor structure through an exploratory factor analysis. In this analysis, individual variables loaded on two factors we have labeled as Overall Cognitive Ability were number series, calculation, concept formation, similarities, auditory working memory, word attack, and picture vocabulary and as Need for Cognition were cognitive effort and cognitive enjoyment. Items loading on each of the two factors presented a loading above 0.3 (loadings in bold), while the loading on the other factor was below that level. The two-factor solution with an oblimin rotation presented the best statistic values when compared with other factor solutions and rotations.

Variable [Missing]	Total (1,174)	Cognitive Enjoyment<61.1 (562)	Cognitive Enjoyment ≥ 61.1 (612)	p
Female	639 (54.4%)	341 (60.7%)	298 (48.7%)	<0.001
Age (years) [0]	64.7 (± 10.2)	66.2 (± 10.5)	63.4 (± 9.82)	<0.001
Birth year [0]	1,942 (± 10.3)	1,940 (± 10.6)	1,943 (± 9.81)	<0.001
Education [0]				<0.001
- College	580 (49.4%)	269 (47.9%)	311 (50.8%)	
- Elementary	22 (1.9%)	17 (3%)	5 (0.8%)	
- High school	302 (25.7%)	214 (38.1%)	88 (14.4%)	
- More years of college	270 (23%)	62 (11%)	208 (34%)	
Race [2]				0.068
- White/ Caucasian	1,068 (91.1%)	500 (89.1%)	568 (93%)	
- Black/African American	63 (5.4%)	38 (6.8%)	25 (4.1%)	
- American Indian	8 (0.7%)	7 (1.2%)	1 (0.2%)	
- Alaska Native	1 (0.1%)	1 (0.2%)	0 (0%)	
- Asian	26 (2.2%)	12 (2.1%)	14 (2.3%)	
- Pacific Islander	1 (0.1%)	0 (0%)	1 (0.2%)	
- Other	5 (0.4%)	3 (0.5%)	2 (0.3%)	
Marital status [0]				0.022
- Married	765 (65.2%)	358 (63.7%)	407 (66.5%)	
- With a partner	37 (3.2%)	11 (2%)	26 (4.2%)	
- Did not report	372 (31.7%)	193 (34.3%)	179 (29.2%)	

Table 1: Participants' characteristics stratified by upper vs. lower 50th percentile cognitive enjoyment scores.

Variable [Missing]	Total (1,174)	Cognitive Effort<69.4 (579)	Cognitive Effort ≥ 69.4 (595)	p
Female	639 (54.4%)	337 (58.2%)	302 (50.8%)	0.012
Age (years) [0]	64.7 (± 10.2)	66.7 (± 10.7)	62.7 (± 9.35)	<0.001
Birth year [0]	1,942 (± 10.3)	1,940 (± 10.8)	1,944 (± 9.35)	<0.001
Education [0]				<0.001
- College	580 (49.4%)	272 (47%)	308 (51.8%)	
- Elementary	22 (1.9%)	18 (3.1%)	4 (0.7%)	
- High school	302 (25.7%)	209 (36.1%)	93 (15.6%)	
- More years of college	270 (23%)	80 (13.8%)	190 (31.9%)	
Race [2]				0.006
- White/Caucasian	1,068 (91.1%)	509 (88.1%)	559 (94.1%)	
- Black/African American	63 (5.4%)	42 (7.3%)	21 (3.5%)	
- American Indian	8 (0.7%)	5 (0.9%)	3 (0.5%)	
- Alaska Native	1 (0.1%)	0 (0%)	1 (0.2%)	
- Asian	26 (2.2%)	16 (2.8%)	10 (1.7%)	
- Pacific Islander	1 (0.1%)	1 (0.2%)	0 (0%)	
- Other	5 (0.4%)	5 (0.9%)	0 (0%)	
Marital status [0]				0.029
- Married	765 (65.2%)	365 (63%)	400 (67.2%)	
- With a partner	37 (3.2%)	13 (2.2%)	24 (4%)	
- Did not report	372 (31.7%)	201 (34.7%)	171 (28.7%)	

Table 2: Participant characteristics stratified by cognitive effort scores.

Variables	Overall Cognitive ability	Need for Cognition
Number Series	0.8779	-0.0267
Calculation	0.7478	0.0451
Concept Formation	0.6506	-0.0463
Similarities	0.6281	0.1062
Auditory Working Memory	0.5985	-0.0562
Word Attack	0.5039	-0.0385
Picture Vocabulary	0.4443	0.1039
Cognitive Effort	0.0164	0.7361
Cognitive Enjoyment	-0.0029	0.7324

Table 3: Exploratory factor analysis.

Bifactor confirmatory analysis

A confirmatory factor analysis was then conducted, using the factor solution found in our exploratory analysis which was also present in the original scale validation [34]. Figure 1 presents our results, demonstrating that correlations between individual scores and the overall G factor were consistently higher than the correlations with the Need for Cognition and Overall Cognitive Ability constructs.

SEM

Finally, we used a structural equation model to measure the correlation between the Overall Cognitive Ability and Need for Cognition constructs. Overall Cognitive Ability demonstrated correlations with word attack, auditory working memory, calculation, concept formation, picture vocabulary, number series and similarities with coefficient values 1, 0.8, 0.9, 1.1, 0.7, 1.3 and 0.4, respectively. Need

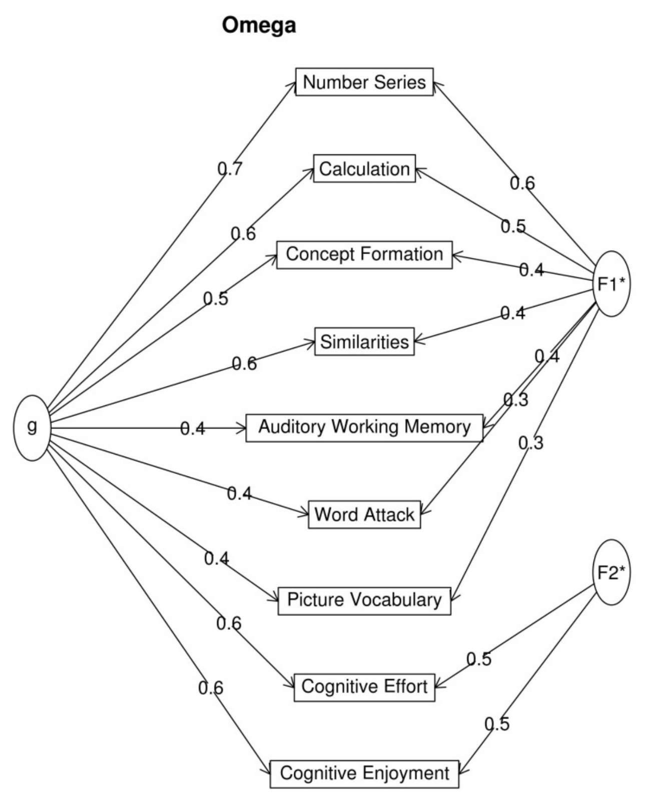

Figure 1: Bifactor model.

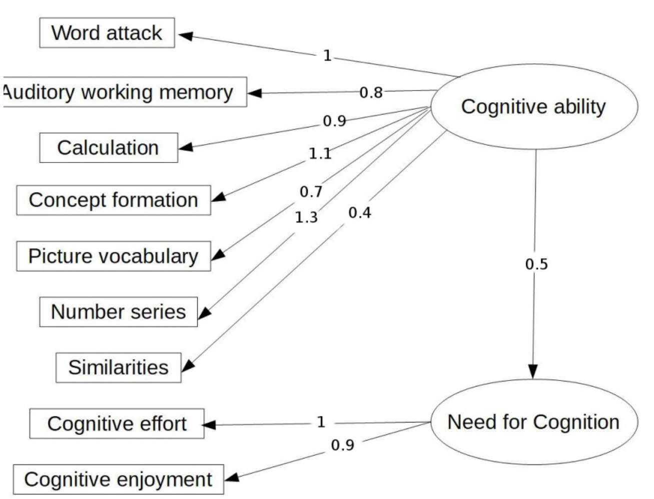

Figure 2: Structural equation model evaluating the correlation between overall cognitive ability and need for cognition.

for Cognition was correlated with cognitive effort (1) and cognitive enjoyment (0.9). Cognitive ability and Need for Cognition were also correlated (0.5) (Figure 2).

Fit measures

The following measures of fit were obtained, all confirming an excellent fit: Comparative Fit Index=0.937, Tucker-Lewis Index=0.913, Non-Normed Fit Index=0.913, Relative Fit Index=0.904, Normed Fit Index=0.93, Incremental Fit Index=0.938, Relative Non-centrality Index=0.937, Root Mean Square Error of Approximation (RMSEA)=0.086, Lower bound of 95% confidence interval for RMSEA=0.077, Upper bound of 95% confidence interval for RMSEA=0.097, Chi Square=238 with 26 degrees of freedom; p-value for obtained chi-squared value and degrees of freedom <0.001, total sample size=1093, Critical n for alpha 0.01=210, Goodness-of-Fit Index=0.948, adjusted goodness of fit index=0.91, McDonald Fit Index=0.907.

Discussion

To the best of our knowledge, this is the first study evaluating the relationship between Need for Cognition and various cognitive ability constructs in a sample that mirrors a population sample. Although Need for Cognition and Overall Cognitive Ability can be plausibly depicted as two separate constructs, both are strongly correlated as demonstrated by a bi-factor confirmatory analysis as well as a structural equation model. These results point to cognitive ability being a paramount construct in the pursuit of cognitively-stimulating activities.

Need for Cognition is a broad concept representing the quest for intellectually-strenuous tasks [35], which can also be perceived as an impulse leading people toward the solution of arduous problems [36]. Individuals with low levels of Need for Cognition are less likely to be actively involved in information or advice gathering when solving difficult problems [37], ultimately leading researchers to suggest that Need for Cognition might affect cognitive reactions [38]. However, to date, the hypothesis of an association between Need for Cognition and cognitive levels has been faced with conflicting evidence.

Many studies have highlighted positive effects of Need for Cognition on cognitive function. For instance, a systematic review outlined the benefits of cognitively-stimulating activities on selected cognitive functions including measures of memory and subjective cognitive function [39]. Specifically, cognitive training was associated with improved performance on memory (face-name recall, immediate recall and paired associates) as well as subjective cognitive function. These findings have been corroborated by observational studies restricted to non-population findings demonstrating that increased Need for Cognition levels have a positive effect on neurocognitive ability [6,40]. Finally, it has been shown that individuals less likely to solve burdensome tasks are less likely to have high levels of ability to use numbers, a high cognitive function that is essential for decision making [36].

In contrast with these previous findings, some studies found no significant association between cognitively-stimulating activities and cognitive functioning. This lack of association was found among samples involving a mix of young and elderly patients [41], ultimately providing no support for the hypothesis that cognitive-stimulating environments might either enhance or even preserve a cognitive function level that would otherwise decline with age. Similarly, other authors have demonstrated that selected cognitive-training activities such as memory training did not result in higher specific cognitive abilities that could be translated into any benefit in activities of daily living [42].

When contrasting these two sets of results, one possible explanation was that cognitively-stimulating results might indeed be relevant. Such importance is however contextual because stimulation is one of many factors that might contribute toward the preservation or enhancement of cognitive function. The literature presents support for many such factors that might enhance cognitive levels including younger age, female gender, high educational level, ethnicity, and the absence of disability or comorbidities such as diabetes or stroke [43]. Previous findings suggest that males tend to be both the lowest and the highest performers in terms of their reasoning abilities [44]. This is contradictory to our results which portray women as having higher cognitive enjoyment and lower cognitive effort scores than their male counterparts. Not only does education provide a cognitive advantage such that persons with more years of education present higher levels of cognitive function throughout adulthood, but it also makes subjects more resilient to any given level of cognitive impairment [45]. In alignment with our results, previous studies demonstrated that subjects with educational levels as high as college presented higher cognitive effort and enjoyment scores than those with lower educational levels [45]. This is likely explained by the relation between the level of cognitive function and senile plaques, which differ by level of education, which can influence the functional organization of the human brain [45]. This has resulted in support for education affecting several cognitive abilities, providing some form of cognitive reserve that reduces the deleterious effect of senile plaques on cognitive functions. Pertaining to the role of marital status, similar to previous studies, our results demonstrate that married subjects presented higher cognitive effort and enjoyment scores. A possible explanation could be their increased social engagement and participation in cognitively stimulating activities (participation in religious activities and various community/recreational activities), which is thought to increase neurogenesis, synaptogenesis, and dendritic complexity [46]. Of importance, a combination of biological and socio-environmental factors have also been listed as contributors, including thyroid function, brain receptors, antenatal and early life stressors (nutrition, infection) [47], income, urban status and self-reported impaired memory as predictors of poor cognitive function [48]. In other words, when local rather than representative samples are chosen, previous studies might have selected subgroups that were influenced by many of these factors, ultimately leading to the differences observed in the literature. In contrast, our study focused on a sample that mirrors the population-based Health Retirement Survey.

Although our findings fill a unique gap in the literature, it does have some limitations inherent to an observational design. First, although efforts were made to address missing rates, some variables presented unusually high rates. To minimize this limitation, imputation algorithms were used followed by sensitivity analyses. Second, as outlined above, we did not have variables to control for factors that might affect the association between Need for Cognition and cognitive function, including biological and social factors.

Conclusion

In conclusion, Need for Cognition and neurocognitive ability is strongly correlated and could perhaps be constructed as a single factor. Given the close connection between these two constructs, health-related policies should focus on both attempting to enhance and monitor cognitive ability and need for cognition. Future research should also focus on assessing the relationship between the Need for Cognition and cognitive function in the context of a multitude of other factors, thus determining the contribution of individual factors under different circumstances.

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