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Can Personality Protect Against Cognitive Decline in Aging? A 25-year Longitudinal Study of Experiential Openness, Neuroplasticity and Cognitive Aging

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ABSTRACT

Studies of neurocognition across the lifespan have demonstrated gradual declines among healthy adults in the domains of memory, problem-solving, sensory processing, executive functioning, and processing speed. However, recent advances in the field of personality neuroscience have discovered significant differences between and within individuals' capacity to compensate for these differences, ultimately altering the degree and magnitude of neurocognitive decline in the aging process.

Experiential Openness (EO), first proposed by Costa and McCrae in their five-factor model of personality has been found to be positively related to preserved autobiographical memory recall and reminiscing activity. Additionally, Ihle, Zuber, Gouveia, et. al. found that EO adults engaged in more leisure time activities which served to mediate smaller cognitive declines in executive functioning relative to their Experientially Closed (EC) counterparts.

The current study recruited an initial cohort of 220 well-educated and physically healthy adults aged 55-57 who volunteered to complete a total of six one-hour neurocognitive testing sessions (i.e.once every five years) over a 25 year period. Participants initially completed the NEO Personality Inventory. Cognitive testing included standardized measures of immediate and incidental memory as well as executive functioning.

Results reflected that EO participants demonstrated better preservation of executive functioning, incidental memory, and immediate memory functions into late adulthood over their EC counterparts. Furthermore, although both personality groups eventually displayed cognitive decline into their late 70's and 80's, EC personalities displayed steeper rates of decline (i.e. slope gradients) at younger ages.

These findings mirror prior longitudinal and cross-sectional studies which employed a variety of different cognitive measures across varying testing ages and lend support to the notion that personality differences may account for preserved differentiation and differential preservation of neurocognition among non-demented persons. These findings suggest that personality traits which promote active and novel sensory engagement may necessarily stimulate hippocampal neurogenesis in older adults through the formation of new neuronal pathways. Understanding and recognizing these individual differences in critical areas of cognitive processing may prove essential to improving the functional capacities and quality of life for older persons.

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Introduction

In general, cognitive aging has been characterized by a decline in cognitive functions, such as declining executive functions, slowing of processing speed, impaired problem-solving competence, and eroding memory and concentration skills [1-5].

A plethora of research has identified multiple risk factors associated with cognitive decline in aging, including smoking, diabetes mellitus, mid-life obesity, physical inactivity, hypertension, and traumatic head injury [6]. However, wide variations within and between older individuals have also been noted. These differences have been studied extensively and multiple biological, psychosocial, and environmental factors have been linked to the preservation of cognitive functioning in healthy older adults [7].

In particular, the relationship between the personality trait Openness to Experience and the cognitive aging process has received considerable attention since the introduction of the foundational model of Five Factor Model of Personality was introduced by Costa and McCrae in 1978 [8-11]. According to Costa and McCrae, persons scoring high in Openness to Experience tend to be intellectually curious, creative, and imaginative with diverse interests and a propensity to explore and engage abstract interests and information [1]. Persons scoring low in Openness to Experience (i.e. Closed to Experience) have been characterized as less adventurous, behaviorally rigid, ideologically dogmatic, and emotionally constricted with a diminished need for fantasy and stimulating information.

As the field of personality neuroscience advances, the roles of peripheral inflammatory markers (e.g. Interlukin, tumor necrosis factor, C-reactive protein, etc.) and dopamine have been studied and implicated as possible contributors to individual differences in rates of cognitive decline across the aging process [12-14].

Openness to Experience has been found, in cross-sectional studies, to be positively related to older adults' preservation of autobiographical memories more active physical and cognitive engagement and greater executive functioning reserve [2,3,15,16].

Longitudinal studies, although limited, have demonstrated associations between personality and cognitive functioning in older adults. In a particularly robust national study of 13,987 participants tested twice over a four-year period, Luchetti et. al. concluded that cognitive decline in memory was associated with higher Neuroticism but greater cognitive performance was found in participants scoring higher in Conscientiousness and Openness to Experience. Indeed, Openness to Experience was found in the Seattle Longitudinal Study to be the personality characteristic most significantly associated with preserved cognitive functioning into late adulthood, leading Sharp et. al. to postulate that perhaps openness may in fact constitute "a behavioral pathway by which cognitive engagement is associated with lower risk of cognitive decline or dementia" [17,18].

Longitudinal analyses of personality features and cognitive aging have also demonstrated consistent associations between Openness to Experience and cognitive reserve in older adults. Sharp, Reynolds, Peterson, and Gatz studied 857 older Swedish adults twice over a six year period and concluded that Openness to Experience was associated with higher performance on cognitive testing, suggesting slower cognitive decline in this aging cohort [18].

In general, the mediating roles of education, cognitive reserve, intellectual complexity of occupation, systemic inflammatory markers, and active social/intellectual engagement have all been implicated in cross-sectional studies demonstrating the positive association between Openness to Experience and the preservation of cognitive functioning late in adulthood [3,18-21].

Openness to Experience has also been associated, in a cross-sectional analysis of 720 elderly individuals without dementia, with preserved verbal fluency, semantic memory, episodic memory, and executive functioning [22].

Neuroplasticity, the brain's ability to change and adapt to experiences, may help explain how individuals open to new experiences tend to demonstrate preserved memory and executive functioning into advanced age. Neuroplasticity and subventricular neurogenesis have been suggested as likely factors responsible for the retention and preservation of human learning in addition to protecting the brain from memory and executive functioning declines [7,8]. It is certainly conceivable that neuroplasticity and recent advances in the study of neurogenesis in older adults will help provide the theoretical and biological framework for better understanding of adult differences in cognitive aging [23,24].

Purpose

The purpose of this study was to measure the rate and depth (i.e. slope) of decline in cognitive functioning, if any, between and within individuals on the basis of age and personality differences, namely Openness versus Closedness to Experience. This study is distinguished from other contemporary longitudinal analyses of personality and cognitive functioning by the fact that participants were followed over 25 years between the ages of 55-82 and completed a battery of cognitive tests assessing executive functioning, complex problem solving, incidental memory, and immediate memory.

Methods

This is a moderately sized, community-based sample recruited in a longitudinal study format and designed to investigate the impact of age and personality on cognitive functioning in a cohort of 220 healthy adults initially aged 55-57 years old. Cognitive testing was performed every five years commencing in 1995 and proceeded every five years until 2020 when the remaining participants were 80-82 years old.

Setting

Volunteer participants were recruited (beginning in 1994) from 12 unrelated medical, social services, non-profit, and senior services agencies in Anchorage, Alaska. The author visited each agency on several occasions meeting for the purpose of recruiting participants among the professional staff. A detailed explanation of the purposes and methods of the study along with a detailed review of the commitment required of all participants was offered verbally and in writing.

Participants

An initial cohort of 220 volunteers was recruited from 12 different healthcare-related agencies. The cohort was highly educated (mean years of education=15.88 years) and predominantly female gender (58%). All 220 participants were initially employed full-time and in good physical and mental health. Participants completed the Cornell Medical Index and those with a history of neurological complications (e.g. stroke, traumatic brain injury, neurodegenerative disorders, seizure disorders, etc.), substance abuse, untreated/unstable cardiovascular pathology, and/or diabetes mellitus were excluded from the study [25].

Participants initially completed the NEO Personality Inventory which was designed to assess an individual's propensity to engage in fantasy, esthetics, feelings, activities, actions, values, abstractions, and ideas [1,26,27]. The total Openness score can be regarded as a measure of how people engage with various percepts, patterns, and perspectives with high scores (above the median score for Openness) reflecting an interest in abstract information, the pursuit of complex sensory stimulation, and in general a greater interest in depth of cognitive exploration. Low Openness scores (below the median for Openness) reflected participants who see themselves as conventional, traditional, as disliking change, dogmatic, and tending to be resistant to new ideas.

Of the 220 participants in the initial cohort, 115 scored high in Openness to Experience with 105 scoring low in Openness to Experience. These groups were thereafter designated as Open to Experience versus Closed to Experience participants.

Participants consented to complete cognitive testing (Outcome Variables) once every five years (i.e. 1995, 2000, 2005, 2010, 2015, 2020) in the author's outpatient clinic.

It should be noted that participant attrition was unusually high likely due to the tendency for many aging Alaskans to relocate out of Alaska following their retirement. Additionally, the highest percentage of participant attrition occurred during the Covid-19 pandemic 2019-2020.

Outcome Variables

- The Stroop Test is a task consistently associated with lateral prefrontal cortex activation with fMRI activation also implicating the inferior temporal/parietal cortices and caudate nuclei [28-30]. The test is a measure of cognitive control and ability to focus upon a goal by inhibiting a well-learned, habitual response in lieu of a novel response. The Trenerry Version includes a Color Naming Task followed by a Color-Word (Interference) Task in which the participant is given 120 seconds to complete (Total Score=0-112).
- The Category Test is a task involving abstract reasoning and concept formation requiring cognitive flexibility in order to interpret and solve complex problems [31,32]. The task requires an ability to extrapolate information from exposure to novel stimuli and thus learn from experience. Although the Category Test was originally designed to detect frontal lobe damage and has been found to be a sensitive measure of brain injury in general, the test has demonstrated no consistent relation to specific brain regions, structures, or laterality of damage [33,34]. The computerized (adult) version consists of seven subtests (Total Score=0-208) [35].
- The Bender Visual-Motor Gestalt Test was originally designed to provide a non-verbal assessment of neuropsychological functioning [36]. The test is used as a measure of visual memory, perception, and constructional abilities. Numerous studies have demonstrated that the Bender recall test is strongly correlated to the Benton Visual Retention Test and that both measures can be effectively used to reliably identify persons experiencing memory deficits including subcortical dementia [37]. The BVMGT requires the participant to copy nine figures on a sheet of paper. After a 20-minute delay filled with unrelated cognitive tasks, the Recall Test procedure is a reliable measure of incidental memory and requires the participant to reconstruct from memory on a clean sheet of paper as many of the original nine designs as they can recall (Total Score=0-9).
- The Digit Span-Reverse/Backwards is a measure of executive functioning that requires an active engagement between passive memory storage and active manipulation of the information being held in storage. The test is widely considered to be extremely sensitive to even minimal brain dysfunction and consequently is widely used by neuropsychologists assessing immediate memory [38]. The task requires the participant to recite a series of randomly presented numbers of between 2-8 digit length in the reverse order in which it was originally presented (Total Score=0-8).

Results

Table 1 reflects the mean scores for each cognitive test administered as a function of personality type (Open v. Closed) and age of participant at the time of their serial testing. Total number of participants at the time of the testing for each age group is reflected by the N listed in the left-hand margin. Number of unique participants within each personality cell is reflected by the n beneath each mean score.

Table 1: Cognitive Performance by Age and Personality

Cognitive Performance (mean scores reported)

	Stroop Interference Trial		Category Test		Digit Span Reverse		Bender VMGT Recall	
Personality	**Open**	**Closed**	**Open**	**Closed**	**Open**	**Closed**	**Open**	**Closed**
Test Age: 55-57 N=220	90.28 n=115	88.78 n=105	172.74 n=115	177.74 n=105	5.52 n=115	5.38 n=105	6.75 n=115	6.58 n=105
Test Age: 60-62 N=187	87.15 n=96	83.60 n=91	168.85 n=96	164.40 n=91	5.28 n=96	5.01 n=91	5.45 n=96	4.38 n=91
Test Age: 65-67 N=142	82.71 n=87	67.28 n=55	165.29 n=87	150.72 n=55	4.96 n=87	4.54 n=55	4.28 n=87	4.29 n=55
Test Age: 70-72 N=118	68.12 n=68	47.22 n=50	159.88 n=68	140.78 n=50	4.78 n=68	4.18 n=50	3.58 n=68	2.75 n=50
Test Age: 75-77 N=70	51.12 n=47	38.87 n=23	146.88 n=47	129.13 n=23	4.20 n=47	3.21 n=23	3.22 n=47	1.85 n=23
Test Age: 80-82 N=20	46.28 n=12	29.52 n=8	121.72 n=12	108.48 n=8	3.85 n=12	2.58 n-8	2.15 n=12	0.38 n=8

The same data is reflected graphically to reflect the cognitive performance gradient over time in Figures 1-4. As can be seen, the decline in cognitive functioning is most salient among participants who scored low in Openness (i.e. Closed to Experience personalities). The data reflects cognitive decline among this group begins at an earlier age (i.e. age 60-65) and performance drops more precipitously than their Open to Experience counterparts, especially on executive function (e.g. Stroop Test, Category Test) tasks.

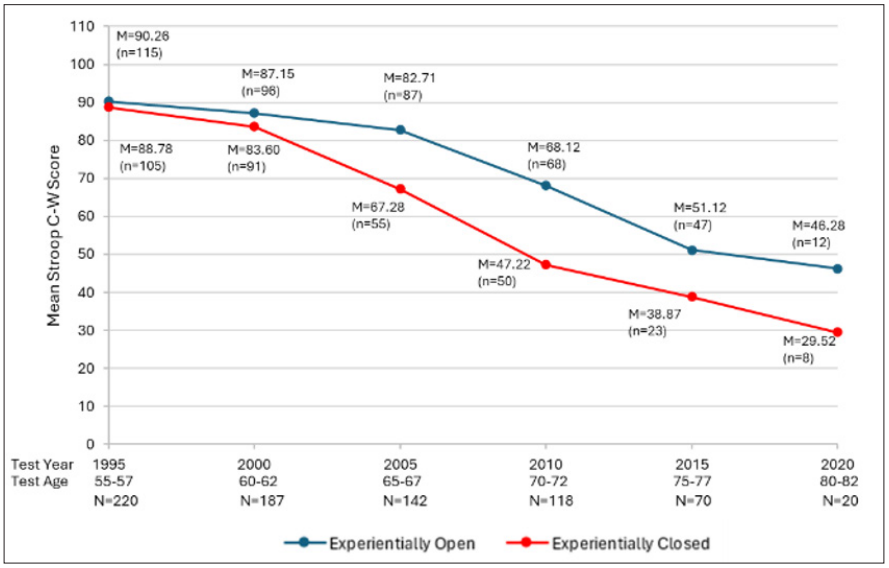

Figure 1: Mean Stroop Test Scores by Age and Personality

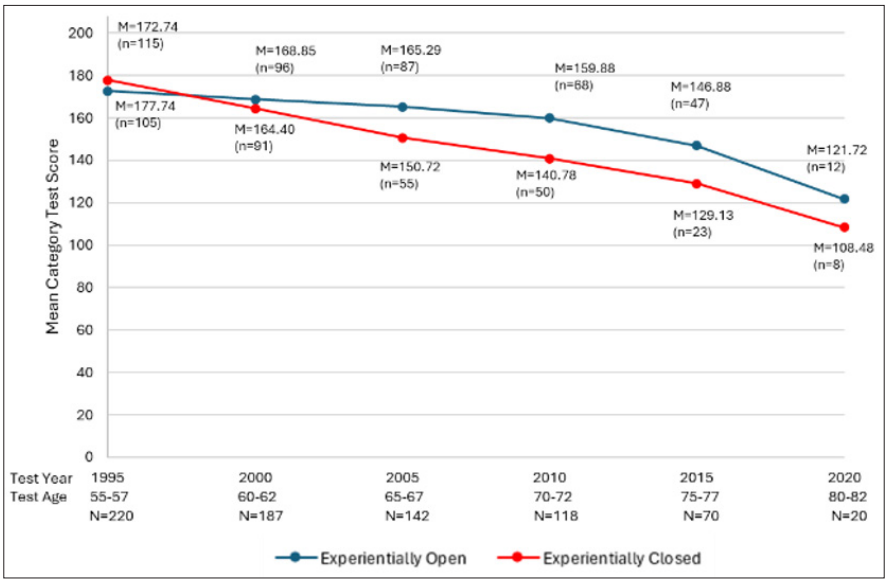

Figure 2: Mean Halstead Category Test Score by Age and Personality

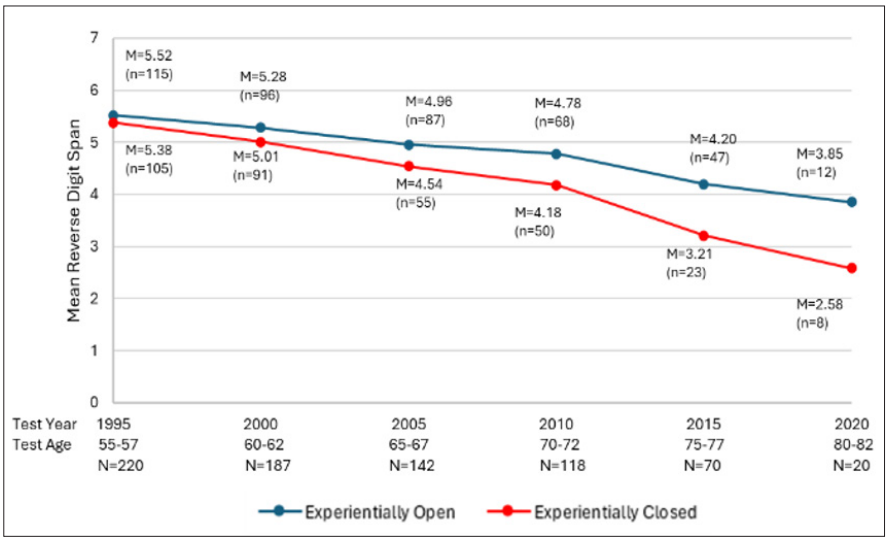

Figure 3: Mean Reverse Digit Span by Age and Personality

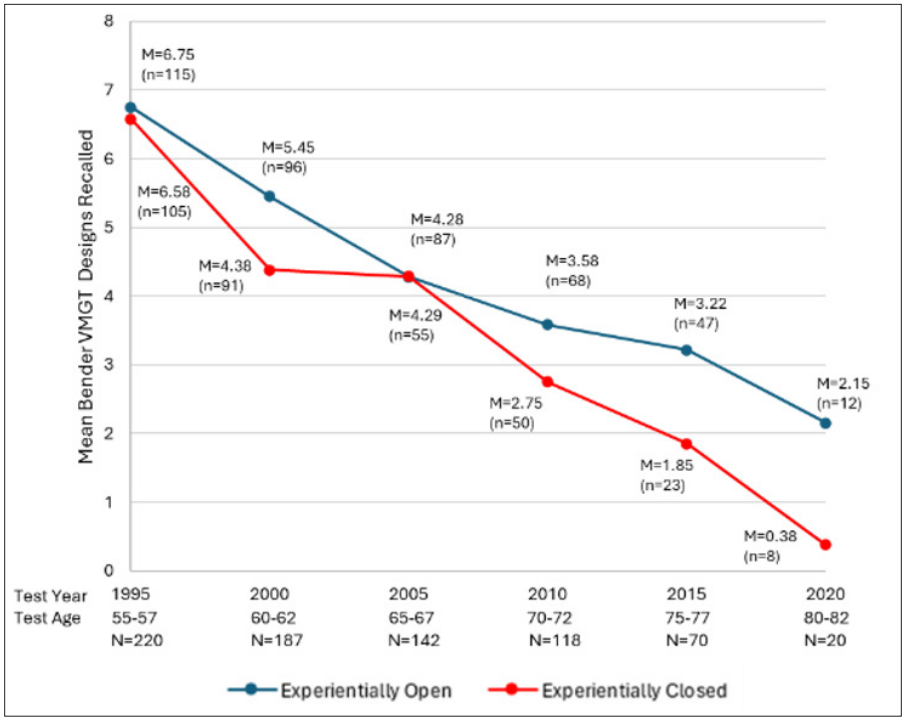

Figure 4: Mean Bender VMGT-Recall Score by Age and Personality

- Figures 1-4 display Experientially Open participants demonstrated better preserved executive function (Stroop, Category tests), incidental memory (Bender Recall test), and immediate memory skills than their Experientially Closed counterparts.
- Experientially Closed participants demonstrated reduced performance on the Category Test, Stroop Test, and Bender Recall Test in their early – mid 70's. This reduced performance was not reflected among Experientially Open participants until they were in their late 70's and early 80's.
- Both personality groups eventually demonstrated cognitive decline into their late 70's and 80's. However, the rate of decline (i.e. slope gradient) was steeper among Experientially Closed participants at a younger age.

Discussion/Implications/Recommendations

- These findings mirror prior longitudinal study results obtained by Sharp et. al. who employed 13 cognitive measures assessing verbal, memory, processing speed, and spatial skills [18]. The current findings which employed immediate memory, incidental memory, and complex problem solving lend support to the notion that personality factors (Experiential Openness) are protective and may reduce (i.e. preserved differentiation) and delay cognitive decline (i.e. differential preservation) among aging, non-dementia participants.
- A theoretical and explanatory mechanism of action underlying these results would be that active cognitive engagement in novel sensory experiences necessitates and ultimately stimulates the formation of new neuronal pathways. Such a process finds support in research demonstrating hippocampal neurogenesis in older non-demented persons.
- Further radiologic studies (i.e. fMRI) are needed to isolate and identify areas of the frontal and subcortical regions of the brain most likely involved in active cognitive engagement during the processing of novel and complex sensory experiences.

Study Strengths

This study recruited a moderately high number of well-educated and healthy volunteers initially willing to commit to serial cognitive testing over a 25-year period. The cognitive testing battery was necessarily limited in scope, intensity, and duration, averaging approximately 45-60 minutes per individual session. A research assistant administered and scored the NEO-PI and therefore the author, who conducted all initial and follow-up cognitive testing sessions, was blind to the participants' personality status until the study was completed and the data was collated/integrated.

Study Weaknesses

This study realized a high rate of participant attrition (91%) over the 25 year duration due to a number of factors which necessarily reduces the significance of the slope gradients observed in cognitive performance. Chief among the attrition factors was the tendency for older Alaskans to relocate after retirement in order to embrace warmer climates and closer family connections. Also not unexpectedly, participant attrition rate (71%) attributable to the COVID19 epidemic occurred between the 2015 and 2020 testing dates. Not all attrition was due to the death of participants. Many participants during this period lost interest in the study or declined further participation due to the fear of potential viral infection. Some were quarantined and unavailable due to COVID 19 restrictions imposed at the time.

Ethics Declarations

The author declares no competing interests. This study was reviewed and approved by the Medical Ethics Research Committee and Medical Staff of the Charter North Hospital on August 10, 1994. All volunteers were provided with a comprehensive introduction to the purposes, methods, and materials incorporated in the study prior to providing their informed and written consent to participate in accordance to the American Psychological Association Ethical Principles and Code of Conduct (adopted in August 1992) [39-41].

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