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The moderating effect of neuroticism and openness in the relationship between age and memory: Implications for cognitive reserve

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ABSTRACT

Previous research has frequently shown the association between age, Neuroticism, and Openness with memory. However, few studies have investigated the interaction of these factors so far. The present study examined whether the relationship between age and memory is moderated by the Neuroticism and Openness using cross-sectional data from a sample of 550 Iranian participants. They completed the Persian version of the NEO five-factor inventory as well as the memory tests from the Sepidar cognitive test battery. The results indicated that Openness was significantly positively associated with episodic, semantic, and working memory, and the unique effect of Openness on episodic and semantic memory was found even after controlling for the effect of years of education, sex, socioeconomic status (SES), and age. Moderation analysis indicated that Openness moderated the relationship between age and semantic memory as well as age and working memory. Moreover, the results showed that the pathway between age and semantic memory was moderated by Neuroticism. This study highlights the interaction between age, personality traits, and memory, which has important theoretical and practical implications for the cognitive reserve in healthy adults.

1. Introduction

Cognitive health is one of the important factors affecting quality of life in older adults (Stites, Harkins, Rubright, & Karlawish, 2018; Williams et al., 2017). In the context of aging, cognitive health is defined by individual's ability to maintain his/her own optimal cognitive function as they age (IOM, 2015). Previous studies suggests that poor cognitive health is associated with numerous problems in aging such as high rate of mental health disorders (e.g., mood, anxiety and substance use disorders), suicidal behavior (Lai, Kaup, Yaffe, & Byers, 2018), difficulty in daily life activities (Nikolova, Demers, & Béland, 2009) and reduced quality of life (Kalaria et al., 2008; Singh, Govil, Kumar, & Kumar, 2017). Although cognitive decline is a natural part of aging process, there are significant inter-individual differences among older adults in cognitive functions (MacPherson, Allerhand, Cox, & Deary, 2019; Monge, Greenwood, Parasuraman, & Strenziok, 2016; Wilson et al., 2002). One of these differences is related to cognitive reserve (CR) which is defined as a set of protective factors against cognitive deterioration occurs as a result of various reasons including aging (Groot et al., 2018; Meng & D'Arcy, 2012; Stern, 2009). Stern (2009) noted that CR make individuals to be more resilient and resistance against age-related brain changes.

Therefore, a critical step in this line of research may identify and measure parameters which are most likely responsible for improvement of CR. As CR cannot be directly measured (Stern, 2009), it is commonly indexed by those activities that are suggested to promote it (Opdebeeck, Martyr, & Clare, 2016). The results of the meta-analysis by Opdebeeck et al. (2016) indicated that educational level, occupational status, and engagement in cognitively stimulating activities were associated with better performance across a broad range of cognitive domain including memory, executive function, visuospatial ability, and language. Neuroimaging studies also reported a significant correlation between the proxies of CR and the activation of brain regions including anterior cingulate cortex and dorsolateral prefrontal cortex in Alzheimer's disease (Colangeli et al., 2016).

Precise definitions of CR not only predict that lifestyle, socio-

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behavioral, and personality factors will correlate to cognitive ability, but also that such factors will moderate the relationship between cognitive ability and brain structure changes (due to injury or aging). Specifically, cognitive ability of individuals with high level of CR should be less dependent on brain structure than those with low CR (Chan et al., 2018; Stern, 2017).

Trait personality characteristics are also related to cognitive functions and may also contribute to individual differences in cognitive decline (Curtis, Windsor, & Soubelet, 2015). Previous studies have reported the association between personality traits and cognitive deterioration, including mild cognitive disorder and Alzheimer's disease (Henriques-Calado, Duarte-Silva, & Ferreira, 2016; Payne & Stine-Morrow, 2018; Terracciano, Stephan, Luchetti, Albanese, & Sutin, 2017). The main personality factors that are indicated to be associated with cognitive functions are Neuroticism and Openness (Aiken-Morgan et al., 2012; Boyle et al., 2010; Henriques-Calado et al., 2016; Soubelet & Salthouse, 2011; Weinstein, Elran Barak, Schnaider Beeri, & Ravona-Springer, 2019; Williams, Suchy, & Kraybill, 2010).

Neuroticism refers to the susceptibility to be emotionally unstable, and to experience negative emotions such as anger, anxiety, and depression (McCrae & John, 1992). Neuroticism has been correlated with lower level of cognitive function in many studies (Boyle et al., 2010; Chapman et al., 2012; Soubelet & Salthouse, 2011; Williams et al., 2010). However, some studies reported no significant correlation (Baker & Bichsel, 2006; Jelicic et al., 2003). Openness refers to the tendency to be creative, curious, sensitive to aesthetics, and open to new ideas and experiences (McCrae & John, 1992). It is expected that individuals with higher level of Openness are more likely to engage in stimulating activities that positively affect verbal ability, spatial ability, memory and processing speed, and are more resilient against age-related changes (Gregory, Nettelbeck, & Wilson, 2010; Sharp, Reynolds, Pedersen, & Gatz, 2010). However, in a longitudinal study by Sharp et al. (2010), it has been demonstrated that Openness was not a predictor for differences in the trajectories of cognitive performance over age.

Although there is substantial evidence supporting associations among age, cognitive functions, and personality factors, few studies have investigated these factors concurrently, and less attention has been paid to the moderating effect of personality on the relationship between age and cognitive functions among adults. Therefore, the present study investigated the hypothesis that personality as a CR proxy can moderate the effect of age on memory.

It should be also noted that a simple correlation between personality traits (Neuroticism and Openness) and cognitive functions is not sufficient to demonstrate that the personality reflects CR. Because it does not provide any information about the relationship between age-related pathology and cognitive performance outcome. Therefore, the present study aims to examine the moderating effect of Neuroticism and Openness factors in the relationship between age and cognitive memory. We hypothesized that (1) Neuroticism and Openness contribute to memory independent of age, education, sex and socioeconomic status (SES); and (2) Neuroticism and Openness moderate the relationship between age and memory.

2. Method

2.1. Participants

The sample of 550 participants consisted of 361 females (65.6%) and 183 males (33.3%). Gender information were missing from 6 (1.1%). Participants were recruited via advertisements in social networks, providing information about the study as well as compensation for those who participate in the study and complete the assessments. Free assessment of memory with a complete report of memory function was used to compensate participants for their time. Participants aged 18–80 years (mean age = 47.41, SD = 14.31) and the mean years of education was 15.28 years (SD = 3.31). They were categorized into five SES categories according to family economy reported by themselves (1–5 values: the first category belonged to expenses less than approximately 140 $/month and the last category pertained to expenses more than about 1700 $/month). Inclusion criteria were age between 18 and 80 years and completion of elementary school (being able to read and write in Farsi). Participants were excluded if they reported a history of brain disorders (e.g., stroke, traumatic brain disorder) as well as visual and auditory impairments. They provided written, informed consent prior to their inclusion in the study.

2.2. Assessments

2.2.1. Personality assessment

Personality trait was assessed using the NEO five-factor inventory (Costa & McCrae, 1992) consists of 60 self-report items. NEO measures five domains of personality, including Neuroticism, Extraversion, Openness, Agreeableness, and Conscientiousness, with 12 items per domain. Items are rated on a 5-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree. The higher-order factors and the facet scales demonstrated high internal consistency (Cronbach's α = 0.86–0.92), as well as convergent and discriminate validity (Costa & McCrae, 1992). We used the Persian version of the questionnaire which has been validated by Roshan Chesly et al. (2006).

2.2.2. Memory assessment

The present study used the computerized tests of memory from the Sepidar cognitive Test battery (Hatami et al., 2020; Mohammad et al., 2020). The battery has been originally developed by Nilsson et al. (1997) and translated into Farsi. The following tests were used in this study to measure episodic, sematic and working memory:

1. **Memorizing of names and faces**: Participants were presented with 16 pictures of children's faces with names (first and last names) and were asked to remember them for further recall (episodic memory).
2. **Recalling of sentences and actions**: This test consists of memorizing and recalling the two lists of 16 sentences with/without enactment. For the list of enactment sentences (e.g., "*give me the pencil*"), participants were asked to learn the sentences by performing the actions and recall them after a short delay (2 min). While for the second list, they were just asked to verbalize the sentences by repeating them verbally and recall them after a 2-minute delay (episodic memory).
3. **Naming as many words as possible in a minute**: For this test, participants were asked to name as many words as possible beginning with the letters from Farsi alphabet, in one-minute. In the second part, participants were asked to name professions beginning with the specific letter (semantic memory).
4. **Free-choice recognition of faces**: In this test, 12 out of 16 pictures presented in the first test (Memorizing of names and faces) were displayed with 12 new pictures. Participants were asked to recognize the familiar images from the new ones (episodic memory).
5. **Force choice recognition of names**: In this test, participants were presented with 16 pictures of children shown in the first test (Memorizing of names and faces). For each picture, four options were provided for participants including first and last names. Participants were asked to recognize the correct option for the target picture (episodic memory).
6. **Recognition and cued recall of nouns**: This test includes a set of incomplete sentences that were presented in the second test (Recalling of sentences and actions). Participants were asked to complete them by recalling the proper verbs or nouns (episodic memory).
7. **Free recalling of words under conditions of focused and divided attention tasks**: After a short break (5 min), participants performed the test of free recall of word lists under conditions of focused and divided attention tasks. For each participant, four lists were

randomly selected from the word lists and presented in a predetermined order of conditions. The concurrent task was to sort a deck of cards into two piles based on their symbols. In the first condition, this task was done during both acquisition and test. In the second condition, the card sorting task was done at acquisition only. In the third condition, the card sorting was done at the test but not at the acquisition and in the last condition, there was no simultaneous task during either acquisition or test (episodic memory).

8. **Corsi block-tapping test and Digit Span Memory Task**: The visuospatial and verbal working memory were measured using the corsi block tapping test and backward digit-span test, respectively. (working memory).

The total episodic memory score was obtained by combining the scores of episodic-related items and the total working memory score was obtained by combining the scores of corsi block and backward digit-span tests.

2.3. Statistical analyses

To test our hypotheses, we used the bivariate correlation, hierarchical regression analyses, and simple slopes plots. Moderator analysis for hypotheses was conducted by using the method described in Howitt and Cramer (2011) which standardizes the predictor, the moderator, and the criterion variables with the purpose of minimizing the impact of multicollinearity, while also creating an interaction variable which is a product of the predictor and moderator. The variables are then entered into a hierarchical multiple regression model. The predictor and moderator variables entered into the first block, and the interaction term entered into second block. A moderating effect is assumed to occur if the interaction term is significant in the model ($p < 0.05$). These scores were then plotted onto an interaction line chart using generate code for visualizing interactions by PROCESS Macro (version 3.0: Hayes, 2017). These plots give a visual representation of how different levels of a moderator variable affect the relationship between age and memory. Simple slope values were calculated by assigning personality as the moderator variable and quantifying low personality trait level as one standard deviation below the mean, average personality trait level as being at the mean, and high personality trait level as one standard deviation above the mean. The data for this project are available via the Open Science Framework (OSF) at https://osf.io/stvwy.

3. Results

3.1. Correlations

Table 1 indicates the means (SD) of age, Neuroticism, Openness, as well as bivariate correlations among the predictor and outcome variables. Age had strong negative correlations with episodic memory ($r = -0.636$, $p < 0.001$), working memory ($r = -0.562$, $p < 0.001$), and had a moderate negative correlation with semantic memory ($r = -0.217$, $p <$ 0.001). Openness was positively associated with episodic memory ($r = 0.270$, $p < 0.001$), semantic memory ($r = 0.294$, $p < 0.001$) and working memory ($r = 0.158$, $p < 0.01$). However, Neuroticism had no significant correlation with memory components ($p > 0.05$).

Table 1
Means, standard deviations and correlations (Pearson's r, two-tailed) between predictor and outcome variables.

Predictor variables	M	SD	Outcome variables		
			Episodic memory	Semantic memory	Working memory
Age	47.41	14.31	−0.636***	−0.217***	−0.562***
Neuroticism	32.44	8.05	0.018	−0.054	−0.015
Openness	38.57	5.18	0.270***	0.294***	0.158**

Note: The number of valid observations ranged from $N = 402$ to $N = 535$ due to the pairwise deletion of cases.
*** $p < 0.001$.
** $p < 0.01$.

3.2. Hierarchical regression

To investigate the relationship between personality and memory, a series of hierarchical multiple regressions were performed (Table 2). Hierarchical regression analyses predicting the unique contribution of personality factors for memory performance after controlling for years of education, sex, SES, and age. Predictor variables were entered into two blocks in the following order: (a) education, sex, SES, and age; (b) Neuroticism, and Openness. Incremental R^2 values and standardized beta coefficients are displayed to show both the unique contribution of each predictor and the amount of variance explained by the subset of predictors.

As shown in Table 2, the total amount of variance explained by the predictor variables for episodic memory, semantic memory, and working memory was equal to 0.511, 0.171, and 0.345, respectively. Among personality traits Openness was a unique predictor for episodic memory ($\beta = 0.107$, $p < 0.01$) and semantic memory ($\beta = 0.245$, $p < 0.001$) but not for working memory. Even though Neuroticism did not correlate with memory, it was negatively related to episodic memory in the regression analysis ($\beta = -0.93$, $p < 0.05$). This might indicate that a suppressor variable (Lancaster, 1999) would influence the analysis conducted such that the non-significant correlation changed to significant effect in the regression analysis. Because the significant relationship observed in the regression analysis may be an artificial effect, this finding is not interpreted or discussed.

3.3. Moderation analysis

Next, moderation analysis was conducted to examine the interactive effect of age and personality factors on memory. Results showed that the interaction between age and Neuroticism was a statistically significant predictor of semantic memory ($B = -0.061$, $p < 0.05$) (see Table 3).

The next step was to probe the statistically significant age by personality interaction on memory. This interaction was also tested by computing simple slopes at the mean, one standard deviation above and below the mean of the personality score. As it was expected, simple slopes analysis revealed that age negatively predicted semantic memory at high ($B = -0.218$, $SE = 0.042$, $t = -5.174$, $p < 0.001$), medium ($B = -0.157$, $SE = 0.031$, $t = -5.056$, $p < 0.001$) and low ($B = -0.095$, $SE = 0.043$, $t = -2.204$, $p < 0.05$) levels of Neuroticism (Fig. 1). This result suggests that although the negative relationship between age and semantic memory was significant at all levels of Neuroticism, participants who have a higher score in Neuroticism show a greater decline in semantic memory as they age.

The results of other interaction model revealed a marginally significant (i.e., approached acceptable levels of statistical significance) moderation effect for Openness in the relationship between age and semantic memory ($B = 0.055$, $p = 0.055$). Given that the interactive effect was exploratory in nature, this effect can be interpreted on a 0.10 alpha level (Durand, 2013). The simple slopes analysis showed that age negatively predicted semantic memory at low ($B = -0.164$, $SE = 0.040$, $t = -4.048$, $p < 0.001$) and medium ($B = -0.110$, $SE = 0.029$, $t = -3.761$, $p < 0.001$) but not at high ($B = -0.055$, $SE = 0.040$, $t = -1.372$, $p = 0.171$) levels of Openness (Fig. 1). This suggests that the rate of decline in semantic memory becomes slower in participants who have a higher score in Openness. More specifically, for individuals with high scores in Openness, the association between age and semantic memory was not significant.

For the moderating effect of the Openness on the relationship between age and working memory, the results of the analysis showed that the Openness significantly moderates this relationship ($B = 0.062$, $p <$

Table 2
Hierarchical regression analyses predicting the unique contribution of personality for the memory after controlling for years of education, sex, SES, and age.

Model	Predictor variables	Episodic memory				Semantic memory				Working memory			
		B	SE	β	ΔR^2	B	SE	β	ΔR^2	B	SE	β	ΔR^2
1	Education	0.048	0.008	0.235***	0.489***	0.064	0.012	0.301***	0.113***	0.044	0.012	0.190***	0.336***
	Sex	−0.277	0.051	−0.205***		−0.032	0.070	−0.023		0.156	0.069	0.106*	
	SES	0.040	0.031	0.050		0.037	0.042	0.044		0.045	0.041	0.052	
	Age	−0.024	0.002	−0.526***		−0.003	0.003	−0.055		−0.023	0.003	−0.470***	
2	Education	0.041	0.008	0.201***	0.021**	0.055	0.012	0.259***	0.058***	0.040	0.012	0.175***	0.009
	Sex	−0.275	0.050	−0.204***		−0.033	0.068	−0.023		0.152	0.069	0.104*	
	SES	−0.033	0.030	0.041		0.018	0.041	0.021		0.047	0.041	0.054	
	Age	−0.024	0.002	−0.542***		−0.002	0.003	−0.040		−0.024	0.003	−0.493***	
	Neuroticism	−0.007	0.003	−0.093*		−0.002	0.004	−0.018		−0.008	0.004	−0.093	
	Openness	0.014	0.005	0.107**		0.033	0.007	0.245***		0.002	0.006	0.016	
	Total R^2				0.511				0.171				0.345

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 3
Interaction terms from the hierarchical multiple regressions of the personality traits as moderators of the relationship between age and memory.

Moderators variables	Episodic memory				Semantic memory				Working memory			
	B	SE	β	sig	B	SE	β	sig	B	SE	β	sig
Neuroticism	−0.003	0.022	−0.004	0.901	−0.061	0.029	−0.093	0.037	0.014	0.028	0.021	0.617
Openness	0.015	0.022	0.024	0.498	0.055	0.028	0.084	0.055	0.062	0.028	0.093	0.026

0.05). The effect of age on working memory was significant at low (B = −0.457, SE = 0.041, $t = -11.089$, $p < 0.001$), medium (B = −0.394, SE = 0.030, $t = -13.304$, $p < 0.001$) and high (B = −0.332, SE = 0.040, $t = -8.195$, $p < 0.001$) levels of Openness (Fig. 1). It means that in participants with higher level of Openness, experienced lower rate of working memory loss.

4. Discussion

The findings of present study can contribute to the existing and relevant evidence by indicating the moderating role of Openness as a personality trait in the relationship between age and cognitive performance. The results of this study showed that Openness was positively correlated with episodic, semantic, and working memory. The unique effect of Openness on episodic and semantic memory was found even after controlling for the influence of years of education, sex, SES, and age.

Several previous studies confirmed the positive effect of Openness to experience on cognitive functioning. For example, Sharp et al. (2010) found that higher Openness to experience was significantly associated with higher performance across all cognitive measures even after adjusting for education, cardiovascular disease, and activities of daily living. Furthermore, Gregory et al. (2010) demonstrated that older adults who are more open to new experiences tend to age more successfully and perform better in cognitive tasks.

Most importantly, in the moderation analysis, we found that the participants with higher level of Openness experience less semantic memory and working memory loss as they age. These results suggest that Openness enable individuals to be more resilient to age-related deficits and become less cognitively impaired. These findings may refer to implications for high CR in individuals with high level of Openness.

A possible mechanism to clarify the relationship between Openness and CR could be related to novelty as a key feature for cognitively enriching. This idea is in agreement with the definition of Openness as an intrinsic desire and ability to be actively and flexibly engaged with novel experiences (DeYoung, Peterson, & Higgins, 2005). In contrast, individuals who had lower score on this personality trait, tend to avoid novelty and are inflexible in their activities and beliefs (Williams, Suchy, & Kraybill, 2013).

Although novelty has not been explicitly considered as a contributor to CR in the literature, several studies have examined the relationship between novelty and cognitive function. For example, Tulving and Kroll (1995) found that the accuracy of explicit episodic recognition was higher for novel than for familiar words. Kormi-Nouri, Nilsson, and Ohta (2005) tested the novelty effect and consistently observed the superiority effects in novel items recognition over the familiar ones. This effect was observed for different languages, materials, and types of encoding.

Furthermore, evidence from animal research suggested that novelty may be the critical component in neural plasticity and cognitive enhancement (Veyrac et al., 2009). Moreover, age-related deficits in long-term potentiation in rats are significantly reduced by exposure to novel environments, and novelty facilitates dentate gyrus LTP (Sierra-Mercado, Dieguez Jr, & Barea-Rodriguez, 2008). For human, it can be argued that individuals with higher level of Openness are more actively and frequently engaged in the novel and cognitively enriching activities. Throughout the lifespan, these novel experiences develop repertoires and reserves that enhance cognitive functions and protect against cognitive decline in aging.

Moreover, we found that the moderating effect of Openness was not the same for different types of memory. In particular, it was revealed that Openness moderates the effect of age on semantic memory and working memory but not on episodic memory. According to the findings of this study and previous studies (e.g., Nyberg, Bäckman, Erngrund, Olofsson, & Nilsson, 1996), episodic memory seems to be more influenced by aging than other types of memory. Episodic memory is based on the fluid intelligence, and semantic memory is a measure of crystallized intelligence (Horn & Cattell, 1966, 1967; Rönnlund, 2003). Numerous studies have shown that, while fluid intelligence declines with age, crystallized intelligence remain constant (Horn & Cattell, 1967; Willis & Baltes, 1980). Thus, this could explain why personality factor such as Openness cannot moderate the effect of age on episodic memory performance.

Another finding of the present study was that Neuroticism moderates the effect of age on semantic memory. Our results showed that individuals with lower level of Neuroticism had lower decline in semantic memory. Neuroticism is characterized by elevated autonomic reactivity and dysregulations in the hypothalamo-pituitary-adrenocortical (HPA)

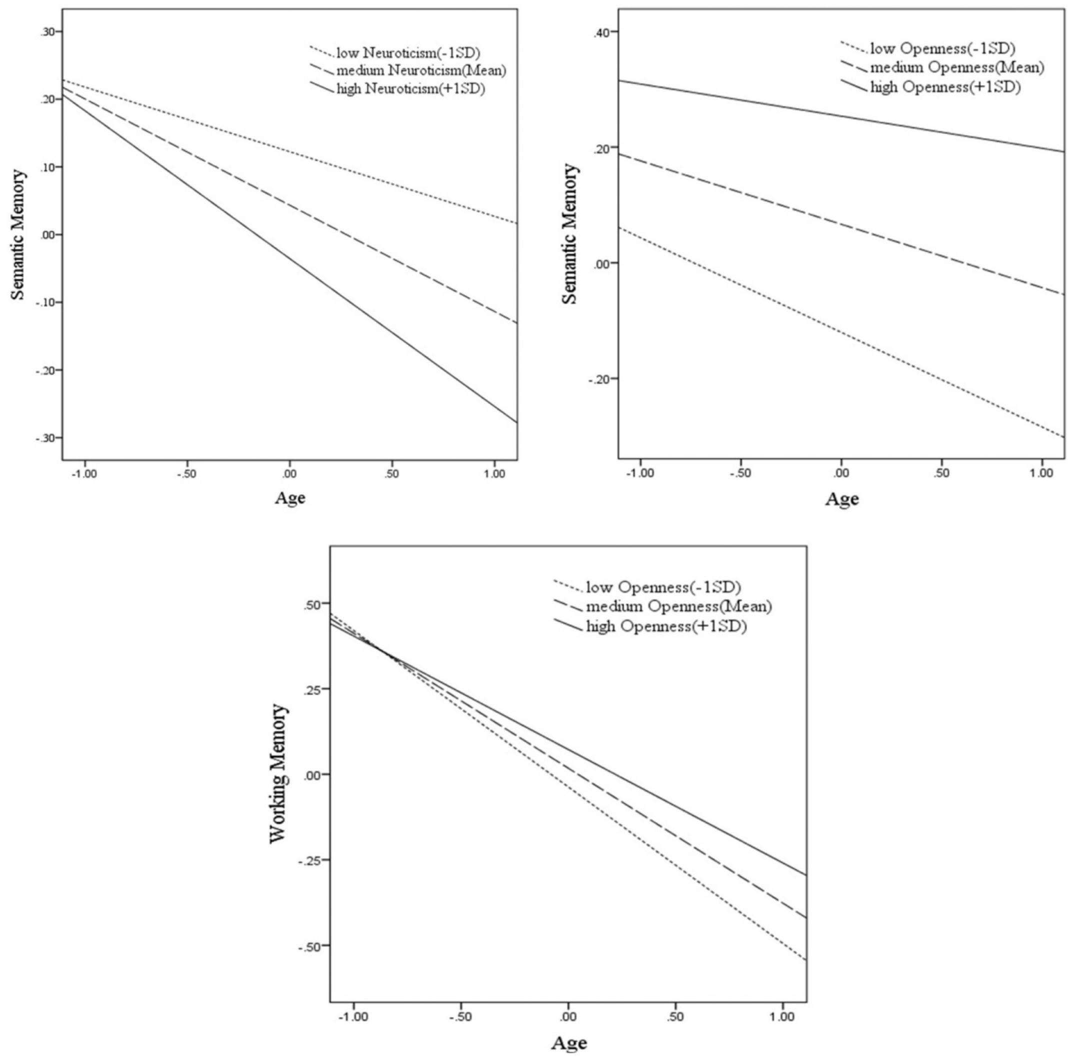

Fig. 1. Simple slopes plots for the effect of age on memory at high, medium, and low levels of personality.

axis (Mangold & Wand, 2006). Throughout a lifetime, chronic dysregulations in the HPA axis and high level of Neuroticism could produce hippocampal atrophy (Sapolsky, Krey, & McEwen, 1986), reduce cerebral gray matter volume (Jackson, Balota, & Head, 2011) and raise neuronal cell destruction and degeneration (Gupta, 2019). This process leads to heightened cognitive decline in old age (Wilson et al., 2005), poor verbal memory, and increase the risk of Alzheimer's disease (Rouch et al., 2019).

Our findings showed that Neuroticism could not moderate the effect of age on episodic and working memory. A possible explanation to clarify these results could be related to the different effects of age on memory types on the one hand, and the relationship between age and Neuroticism on the other. Some studies show that episodic and working memory are more age-sensitive than semantic memory and begin to decline earlier (Nilsson, 2003; Nyberg et al., 2003). A differential aging pattern of episodic and semantic memory was evident from the findings of Rönnlund, Nyberg, Bäckman, and Nilsson (2005). They found small, but reliable improvements from 35 to about 55 years in semantic memory, a period during which episodic memory performance appeared to remain stable. They also found that the decline in episodic memory was substantially greater than the semantic memory after the age of 60. Moreover, a longitudinal study by Pelletier et al. (2017) showed that atrophy in the posterior midline structures for episodic memory occurs earlier than the atrophy of the temporal pole for semantic fluency.

On the other hand, a longitudinal multilevel analysis by Steunenberg, Twisk, Beekman, Deeg, and Kerkhof (2005) showed a small but statistically significant change in Neuroticism level with aging. The figure that they reported in their results depicted a U - formed shape, showing a slight decrease until the age of 70, after which a slight increase is found until the age of 85. Aging is associated with an increase in physical illness and relevant functional limitations as well as a decrease in social resources. These factors are also known to be related to the Neuroticism level (Costa Jr. & McCrae, 1985).

Therefore, decline in working memory and episodic memory may likely begin when the level of elderly Neuroticism is low; hence, these types of memory cannot be influenced by neuroticism. However, when semantic memory declines, the elderly's level of Neuroticism is higher, which may influence the rate of decline.

The findings of the present study should be interpreted considering several limitations. First, the cross-sectional design means that no causal inference can be drawn. Consequently, longitudinal data are needed in order to establish the temporal pattern of the indicated relationships and to better understand the relationships between variables. Second, analyses of the present study give only information about interindividual differences in cognitive functions but do not allow drawing conclusions regarding the cognitive decline in the true sense of the word, which needs to be evaluated with longitudinal data. Third, our sample consisted of highly educated participants, that reduces the generalizability of the results. Future research should investigate these relationships in more diverse samples. Finally, the majority of the sample were women, and there is evidence (e.g. Nilsson, 2003; Pauls, Petermann, & Lepach, 2013) showing that gender could affect on memory and executive functions.

The current study adds to an increasing body of research regarding the impact of age and personality on memory in humans. In conclusion, this study has exhibited that adults who are more open to experience and more emotionally stable (or lack of Neuroticism) tend to age more successfully. Our findings suggest that higher levels of Openness and lowered Neuroticism may be important cognitive reserve for adults and support in maintaining memory functioning in the last years of life. These findings have implications for the design of subsequent interventions for memory improvement. By improving CR and focusing on personality traits, especially Openness and Neuroticism, these interventions may finally result in lower rate of cognitive decline in aging.

CRediT authorship contribution statement

Hossein Karsazi: Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Tara Rezapour:** Writing – original draft, Writing – review & editing. **Reza Kormi-Nouri:** Writing – original draft, Writing – review & editing. **Atieh Mottaghi:** Project administration, Writing – review & editing. **Ehsan Abdekhodaie:** Software, Formal analysis, Writing – review & editing. **Javad Hatami:** Conceptualization, Formal analysis, Writing – review & editing, Supervision.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.paid.2021.110773.

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