



Master's Thesis of Psychology

Negative Effect of Perceived Stress on Cognitive Function was Mediated by Lack of Emotional Closeness

한국 노인의 지각된 스트레스가 인지기능에 미치는 영향: 정서적 유대감의 매개효과

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Abstract

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Perceived stress is known to negatively affect cognitive function in late life and has been reported to have a negative correlation with social network characteristics. In terms of social network characteristics, people with a larger quantity and better quality of social network showed better performance of the cognitive function. Despite the importance of perceived stress and social network characteristics in cognitive function in late life, studies that examined the relationships between these three variables are absent. Therefore, this study aimed to examine whether social network mediates the effect of perceived stress on cognitive function in the older adults in Korea. Also, since neuroticism and depression revealed a very high correlation both with the perceived stress level and cognitive function, this study excluded the effects of the two factors in the whole analysis to focus on the effects of stress on cognitive functions.

One hundred seventy-six community-dwelling adults aged 60 years or older from Korean Social Life, Health, and Aging Project study (KSHAP) underwent perceived stress assessment, social network surveys, and neuropsychological tests. In the result, perceived stress has been shown to have a negative effect on the categorical fluency of executive functions, and emotional closeness of social network quality mediated the association between perceived stress and long-term recall index. An additional mediation analysis was conducted to figure out which of the two subscales of perceived stress had a more significant effect in the mediation model between cognitive function and emotional closeness. Between lack of perceived self-efficacy (LSE) and perceived helplessness (PH), the mediation effect of emotional closeness was significant only in LSE. These results suggest that emotional closeness may be an important factor in explaining the association between perceived stress, especially lack of perceived self-efficacy, and cognitive function.

Keyword: Perceived Stress, Lack of Perceived Self-Efficacy, Cognitive Function in Late Life, Social Network Quantity, Social Network Quality, Emotional Closeness **Student Number:** 2019-23600

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Chapter 1. Introduction

Across the world, the population aging has been a critical challenge. According to the World Population Prospects 2022 published by the UN (United Nations), the population over 65 is growing rapidly, with the proportion of the world population over 65 expected to increase from 10% in 2022 to 16% in 2050. Korean society is not an exception. Korean society is aging rapidly in particular. International organizations such as the UN classify the share of elderly people aged 65 or older as 7% or more of the population as an 'aging society', 14% or more as an 'aged society', and 20% or more as a 'super-aged society'. Based on the 2022 report of Statistics Korea regarding the elderly, 9.018 million, or 17.5% of the total population of Korea are aged 65 or older in 2022 (Statistics Korea, 2022). Korea entered an aged society only 17 years after entering an aging society in 2000. This proportion is expected to continue to increase and exceed 20% for the first time at 20.6% in 2025 and 43.9% in 2060, thereby being estimated that Korea will enter a super-aged society at the fastest level in the world (Statistics Korea, 2022).

As the aging population proliferates, mental and physical changes experienced by the elderly, who account for a large share of the population, are emerging as important social issues beyond individual and family units. In addition, awareness of the importance of enjoying good psychological well-being in late life is increasing. As a result, one essential question regarding what successful aging is came to the fore. The term successful aging refers to the maintenance of physical and cognitive function, and participation in productive activities, in addition to the absence of disease and disability (Rowe & Kahn, 1997; Depp & Jeste, 2006)

However, recent studies have emphasized the importance of psychological and mental health, and adaptation of the older adults along with these three factors, and research results have revealed that psychological factors such as stress have influences on decreased cognitive function (Andel, Crowe, Kareholt, Wastesson, & Parker, 2011; Korten, Sliwinski, Comijs, & Smyth, 2014), accelerated cognitive decline (Wilson et al., 2005; Aggarwal et al., 2014), increased risk of dementia (Wilson, Arnold, Schneider, Li, & Bennett, 2007), and quality of life (Achat et al., 1998; de Frias, & Whyne, 2015; Parsaei, Roohafza, Feizi, Sadeghi, & Sarrafzadegan, 2020).

1.1. Definition of Stress

The conceptual definition of stress has existed in various ways depending on the researcher and the era. The term stress was first coined in the biological context. Cannon (1932) and Selye (1956) regarded the state of stress as threatening the homeostasis maintained by living organisms. In other words, along with the concept of a stressor, an external stimulus that induces a stress state, and a stress response, which is an individual's physiological response to the stressor, stress was considered as a physiological state of the body under the schema of stimulus and response.

Lazarus and Folkman (1984) added individual cognitive evaluation factors and proposed a transactional stress model in which the stress experience is the result of dynamic interactions between the environment and the individual (Fig. 1). The transactional stress model emphasized that factors such as subjective evaluation and coping style based on individual's unique perception, emotion, and cognitive characteristics mediate stressor and stress response. In other words, although the stressor itself may be a stressful experience, most stressors contain the possibility that they may or may not be perceived as a stressful experience depending on the above mediating factors. This model was later widely accepted as a psychological stress concept based on a psychological point of view.



Figure 1. Transactional model of stress (Lazarus & Folkman, 1984)

1.2. Measurement of Stress

In an effort to quantify stress, various stress measurement tools have been developed according to the content of the method. Stress measurement tools can be largely divided into physiological measurement methods and self-report measurement methods (Brannon & Feist, 2000). For physiological measurement, neuroendocrine levels such as stress hormones, cortisol, or neurophysiological levels such as heart rate variability or brain waves are typically used (Choi, Kang, & Woo, 2006). The self-report measurement method is made through a survey, which follows the method of summing up the frequency or degree of ratings for single or multiple questionnaires consisting of statements or interrogative sentences.

The subjective stress scale is a scale composed of the subjective evaluation of the individual, which is the core of the transactional stress model. Cohen &

Williamson (1988) suggested that chronic and global subjective stress that is not based on a specific stress event may have different stress mechanism from event stress. The subjective stress scale does not embrace a specific event in the content of the item, but rather evaluates the individual's cognitive and emotional appraisal of the overall situation, and the degree is evaluated in a Likert method. A representative scale is the Perceived Stress Scale (PSS-14; Cohen, Kamarck, & Mermelstein, 1983).

In addition, subjective stress measures have been reported to predict disease incidence more accurately than stress event measures (Brannon & Feist, 2000; Cohen, Kamarck, & Mermelstein, 1983). Cross-sectional (Hewitt, Flett, & Mosher, 1992) and longitudinal studies (Alspaugh, Stephens, Townsend, Zarit, & Greene, 1999) predicting the severity of depressive symptoms, and cancer-related stress response studies in cancer survivors (Fleer et al., 2006) showed that subjective stress had greater explanatory power than negative stress events in the incidence or severity of the disease. These results suggest the possibility of increasing prediction power by employing a subjective stress scale in terms of studying stress and the development of pathology.

1.3. Stress in Late Life

Old age is a time when the number of stressors increases, such as being vulnerable to diseases, reduced social roles and economic abilities, and bereavement. Especially, in Korea, weakened authority in the family, changes in Korean traditional values, and social support related to the pride of the older adults are the internal and external stresses that Korean elderlies are vulnerable to (Suh, 2007). In addition, the proliferation of the aging population in Korea raises the need for research on the

effects of stress and the psychological state of the older adults, which are closely related to welfare and quality of life (Kim & Kim, 2007).

In old age, the degree of chronic daily stress increases (Smith, 2003), and the level of cortisol, a stress hormone that can be referred to as an indicator of physiological stress, rises (Lupien et al., 1998). Therefore, vulnerability to stress increases, and the negative effects of stress can appear in a more serious state in late life. Stress can also increase the risk of dementia, a mental disorder that is especially important in late life (Johansson et al., 2010; Stuart, & Padgett, 2020). Moreover, with respect to demographic variables, the effect of sex/gender (hereafter referred to as "sex") on perceived stress has been repeatedly confirmed, and it was found to be higher in women (Cohen & Williamson, 1998; Hewitt et al., 1992; Remor, 2006), and the high-education group had lower perceived stress than the low-education group (Cohen & Williamson, 1998; Nielsen, Curtis, Kristensen, & Nielsen, 2008).

1.4. Stress and Cognitive Function

Stress has been studied in relation to the decline of cognitive function. Stress is known to reduce attention span and cause the deterioration of working memory. As a result of investigating the correlation between perceived stress and the performance of the Korean version of the Mini-Mental State Examination (MMSE-K) among older adults in Korea, Choo & Yoo's study (2008) showed negative correlations in orientation, word memory recall, attention, and calculation ability. In addition, in Lee (2005)'s study also targeting the older adults in Korea, perceived stress was negatively correlated with the short-term memory index and long-term memory index calculated by combining the scores related to short-term and long-term memory among the scores of the episodic memory subtest as well as the total score of the Korean Dementia Rating Scale (K-DRS, Chey, 1989), a screening test for dementia. Studies on the relationship between perceived stress and cognitive function have been actively conducted abroad as well. Perceived stress was associated with declines in cognitive function and accelerated declines (Aggarwal et al., 2014; Munoz, Sliwinski, Scott, & Hofer, 2015; Turner et al., 2017; Rimmele, Ballhausen, Ihle and Kliegel, 2022).

In a comprehensive view of the previous studies, perceived stress has a negative correlation with overall cognitive function. However, few studies have focused on the effects of social network characteristics on stress-related cognitive deficits. Also, only a few previous studies did consider neuroticism and depression levels in terms of the effect of perceived stress on cognitive function (Wilson et al., 2005; Aggarwal et al., 2014). Neuroticism works as the tendency to experience emotional distress (Munoz, Sliwinski, Scott, & Hofer, 2015) and is known as a personality risk factor for perceived stress (Luo, Zhang, Cao, & Roberts, 2022) and the development of cognitive impairment and dementia (Terracciano, Stephan, Luchetti, Albanese, & Sutin, 2017). Moreover, high levels of depression are related to the development of higher levels of perceived stress (Fiske, Wetherell, & Gatz, 2009). In an effort to focus on the influence of perceived stress, we controlled the effects of neuroticism and depression levels.

1.5. Stress and Social Network

Dividing into different levels of social integration, we can systematically explore the mechanisms by which social relationships affect health (Berkman, Glass, Brissette, & Seeman, 2000). On a macro level, there are social structural conditions such as culture and politics. Based on this, the structural or quantitative aspect of the social network and the functional or qualitative aspect of the social network are formed. And through this social network, microscopic psychosocial mechanisms such as acquiring social support are formed, which consequently give an influence on individual behavior and health. That is, the social network serves as a path or structure through which the benefits of social relations flow. However, stress has been reported to negatively affect the such social network. Experiences of stress can lead to social withdrawal which can result in impoverished interpersonal relationships (Schulz, Cowan, Cowan, & Brennan, 2004; Patel, Anilkumar, Chattarji, & Buwalda, 2018).

In terms of social network quantity, people with high levels of stress had a smaller number of social relationships over time in adults (Johnson, 1991) and difficulty in maintaining friendships among college students (Kornienk, Schaefe, Weren, Hil, & Granger, 2016). Also, stress was negatively correlated with the social network measured by the number of meetings with family and friends (Nielsen, Curtis, Kristensen, & Nielsen, 2008). One study using objective measures found that higher levels of perceived stress were associated with fewer face-to-face interactions (Madan, Cebrian, Lazer, & Pentland, 2010), and difficulties in engaging in face-to-face interaction and maintaining relationships over time (Dissing, Jørgensen, Gerds, Rod, & Lund, 2019).

In addition, stress has been reported to have negative impacts on social network quality (Bodenmann, Meuwly, & Kayser, 2011; Leidy, Parke, Cladis, Coltrane, & Duffy, 2009). Stress may evoke negative emotions, disturb communication among social relationships (Ledermann, Bodenmann, Rudaz, & Bradbury, 2010), and affect general mental health (Turner, Wheaton, Lloyd, 1995). People with high levels of stress reported having a lower degree of emotional intimacy (Sinclair & Dowdy, 2005) and less emotional social support (Benca-Bachman et al., 2020).

Based on previous studies, highly stressed people seem to be socially withdrawn, have a smaller quantity of social networks, and have a negative association with the quality of social networks. Yet, not many studies have been conducted in older adults. Moreover, since social network quality is suggested as one mechanism by which social network affects mental health (Fiori, Antonucci, & Cortina, 2006), it seems important to explore the effect of social network dividing into social network quantity and quality on cognitive function in older adults.

1.6. Social Network and Cognitive Function

The social network is widely identified as an important predictor of cognitive health and both quantitative and qualitative aspects of the social network have been reported to have a positive association with cognitive function. The reason is that social networks can enhance individuals' access to psychological and material resources and provide cognitive stimulation through social interaction situations. To be more specific, in terms of social network quantity, people with a smaller social network had 1.08 higher odds of cognitive impairment (Kuiper et al., 2016) and performed worse cognitive function, particularly in immediate recall, verbal fluency, and processing speed (Nie et al., 2021).

Also, social network quality including social support and supportive relationships may alleviate negative moods, provide help, and help prevention of cognitive decline (Thomas, Williams-Farrelly, Sauerteig, & Ferraro, 2022). People with a higher degree of emotional closeness presented a higher performance in Mini-Mental State Examination (MMSE) (Lee et al., 2020). Moreover, strong social support measured by perceived positive support from friends and marital status was associated with better performance of cognitive function (Yeh & Liu, 2003). Based on previous studies, it is well-confirmed that social network quantity and quality, and cognitive function are positively correlated.

1.7. Purpose of this Study and Hypothesis

This study aimed to explore whether social network characteristics mediate the relationship between perceived stress and cognitive function independent of neuroticism and depression levels in late life. Studies on the effect of perceived stress on cognitive function have been actively conducted, and many studies have reported social network quantity and quality as protective factors of perceived stress. However, a negative correlation between perceived stress and social network quantity has been consistently reported, and people with a high perceived stress level show retraction of social interactions and have poor social network features.

Therefore, this study aims to investigate whether there is a mediation effect of social network quantity and quality on the relationship between perceived stress and cognitive function. As such, the following hypotheses were tested:

- 1) Perceived stress in late life would be negatively correlated with cognitive function independent of neuroticism and depression levels.
- 2) Social network quantity and quality would mediate the negative

association between perceived stress and cognitive function independent

of neuroticism and depression levels.

Chapter 2. Methodology

2.1. Participants

The participants of this study were recruited through the Korean Social Life, Health, and Aging Project study (KSHAP). The KSHAP is a panel survey conducted since 2011 for an international comparative study on the quality of life and aging process of the older adults in Korea. Healthy older adults aged 60 years or older who live in L- myeon and K-myeon in rural areas of Korea and completed demographic and psychosocial questionnaires, and neuropsychological assessments participated in this study. Education was measured with years of education which was quantified as the actual number of years they spent at school. In order to screen the older adults who are not in a normal aging process, the following exclusion criteria were applied: 1) a history of psychiatric disorders or neurological damage, 2) use of psychiatric drugs, 3) those with visual and hearing problems, and 4) mild cognitive impairment less than 1.5 standard deviations below the mean of the reference group as a result of the State Examination-Dementia Screening (MMSE-DS), 5) clinical levels of cognitive decline (CDR > 0).

As a result, 176 healthy participants were included in this data analysis. There were more women than men (100 women, 77 men), and the mean age was 72.72 years (SD = 6.56). Every participant provided written informed consent and was given compensation for their participation in this study at the end of the session. This study was approved by the Institutional Review Board (IRB) at Seoul National University.

2.2. Measures

2.2.1. Psychological Measurements

The Perceived Stress Scale. The perceived stress scale (PSS; Cohen, Kamarck, & Mermelstein. 1983) was assessed to measure one's perceived stress. Cohen's Perceived Stress Scale was developed based on the theoretical perspective of Lazarus. It is an index of the degree to which a person finds his or her life unpredictable, uncontrollable, and overwhelming which are the core concepts of stress experience. In other words, it measures an individual's subjective appraisal of how stressful his or her life has been over the past month. PSS has been reported as a tool that can be used reliably and appropriately even in the low-education group because the questions are easy to understand (Sharp, Kimmel, Kee, Saltoun, & Chang, 2007).

Initially, a 14-item version was first developed, followed by a 10-item and 4item shortened form. Of these three versions of the perceived stress scale, PSS – 10 is a version of PSS-14 excluding the four items with low factor loadings and shows better reliability and validity (Remor, 2006; Cohen & Williamson, 1988). Therefore, with the advantage of requiring less time in terms of practicality, the current study employed PSS – 10-item version. In addition, PSS is known to have two different subscales, lack of perceived stress (LSE) and perceived helplessness (PH) (Mimura & Griffiths, 2008; Ezzati et al., 2014; Korten et al., 2016; Klein et al., 2016; Jiang, Seng, Zimmerman, Kim, & Lipto, 2017). LSE occurs when failure to cope is attributable to one's abilities or traits rather than an external cause, and PH arises from a perceived inability to cope with situations that require an effective response (Cohen & Wills, 1985).

Validation of the Korean version of the PSS (Hong, Kang, Oh, Park, & Kim, 2016) demonstrated acceptable internal consistency in the 10-item version (Cronbach's alpha = 0.75). We used the Korean version of the Perceived Stress Scale-10 (K-PSS-10) and asked participants to rate the frequency at which they perceived these characteristics within the last month. In order for easier comprehension of the score distribution, we employed a total of 6 – point scales by adding a unit of "Almost always" to the 5 - point scale of the PSS - 10 (Baek, 2010). The responses to questions were coded in a Likert scale format ranging from 0 (never) to 5 (very often). Positively worded questions were reverse-coded, and a total score was obtained by summing the values of all the items. The interpretation of the score is that one with the higher score is having higher levels of perceived stress and the sum score ranges from 0 to 50. LSE consisted of positively worded questions 4,5,7, and 8 such as 'In the last month, how often have you felt confident about your ability to handle your personal problems?' We used reverse coding to make the LSE score (ranging from 0 to 20), and the PH consisted of the negatively worded questions 1, 2, 3, 6, 9, and 10 such as 'In the last month, how often you been upset because of something that happened unexpectedly?' (ranging from 0 to 30).

The Big Five Inventory. The Big Five Inventory (BFI; Pervin & John, 1999) is a measurement of assessing five factors of personality. McCrae and Costa (1987) classified five factors as 'extraversion', 'agreeableness', 'conscientiousness', 'neuroticism', and 'openness'. In this study, the Korean version of BFI (BFI-K), validated by Kim and colleagues (2010), was used to measure neuroticism level, which is related to emotional instability and the degree to which one views the world

as threatening or out of control.

The Geriatric Depression Scale. The Geriatric Depression Scale (GDS; Yesavage et al., 1982) was assessed in order to measure the level of depression of the participants. The GDS is a self-report questionnaire consisting of 30 yes-or-no questions about symptoms that can commonly appear in late-life depression (Montorio & Izal, 1996). Examples of the items are as follows: "Are you basically satisfied with your life?"; "Have you dropped many of your activities and interests?"; "Do you worry a lot about the past?"; "Do you frequently feel like crying?"; "Do you have trouble concentrating?". Korean version of the GDS translated and validated by Jung et al. (1997) was used in this study.

2.2.2. Neuropsychological Assessment

MMSE-DS was conducted to identify the overall cognitive function level of the study participants and to determine whether they had cognitive impairment (Han et al., 2010). In addition, the following neuropsychological assessments were used to attain indices for episodic memory, semantic memory, processing speed, and executive function (Table 1). Global cognition score, a composite of all domains of cognitive function, was created by converting the raw scores on each test to z scores based on the mean and standard deviation (SD) and then averaging the z scores. Higher scores indicate better cognitive function (Wilson et al., 2009; Aggarwal et al., 2014). Since Trail-Making Test A measures time to completion, when it comes to the global cognition score, its z score was reversely coded.

Measurement of Episodic Memory

Elderly Verbal Learning Test included in Elderly Memory disorder Scale (EMS; Chey, 2007) to measure verbal and non-verbal episodic memory function in older adults, Elderly Verbal Learning Test (EVLT), Story Recall Test (SRT), and Simple Rey Figure Test (SRFT) were used. In addition, the global cognition score was computed based on standardized scores of all examinations.

EVLT is a word list learning task based on the California Verbal Learning (Delis et al., 1987), measuring verbal learning and memory. A list of nine words from three distinct categories is presented to the participants over five trials. The list of words belonging to the categories of fruits, animals, and home appliances, and groups with little influence from education, sociocultural class, and sex were selected (Chey, Lee, Kim & Kim, 2006). On each trial, the participant is immediately asked to repeat the items that he or she had heard in order to facilitate learning. Then after a delay of 20 to 30 minutes, the participant is asked to recall the items that he or she had learned (delayed recall). Finally, the participant is given a list of random words including the nine words presented during the learning trial, and is asked whether he or she remembers learning the word (delayed recognition). All recall trials consisted of a free recall trial without cues and a cued-recall trial in which the three semantic categories were heard and recalled.

SRT is a task to listen to and recall events presented in a logical sequence. It is qualitatively different from the word list learning test in that it requires understanding the content and structure of the presented phrase, and at the same time reconstructing the story through personal memory or cultural background. The test consists of immediate recall that recalls immediately after hearing a story, delayed recall that proceeds after 20 to 30 minutes, and recognition task. Scores are scored according to 24 story units and 6 subject units, and the total score was used in this study.

SRFT is a test that measures non-verbal episodic memory function. SRFT is a simplified version of the Rey-Osterrieth Complex Figure Task (RCFT; Rey, 1941; Osterrieth, 1944), wherein visuospatial construction and spatial learning can be measured. The participants are asked to copy a sample figure which is composed of simple geometric features on a blank piece of paper. Then immediate recollection is performed after the removal of the stimulus and copy, and delayed recall and recognition are performed after 20 to 30 minutes have elapsed. The test results reflect compositional ability or perceptual organizing ability, and the effectiveness of long-term consolidation of spatiotemporal working memory and stimuli can be measured through delayed recall trials. Since the copy trial provides a baseline performance for spatiotemporal composition ability, the immediate recall and delayed recall scores added by the points deducted in this stage were used as the correction score.

From the performance of these three tasks, the long-term memory recall index (ie., recall index) and long-term memory recognition index (ie., recognition index) are calculated. The indexes were measured by performance score over total number of trials. The recall index equals the sum of the average performance in the delayed recall tasks of the EVLT, SRFT, and SRT. The recognition index equals the sum of the average performance in the delayed recognition tasks of the EVLT, SRFT, and SRT.

Recall Index = (EVLT delayed free recall / 9) + (SRFT delayed free recall /16) + (SRT delayed free recall / 30)

Recognition Index = (EVLT recognition / 30) + (SRFT recognition / 20) + (SRT recognition / 10).

Measurement of Semantic Memory

The vocabulary subtask of the Korean version of the Wechsler Adult Intelligence Scale 4th edition (K-WAIS-IV; Hwang et al., 2012) measures various cognitive abilities such as semantic knowledge, long-term memory, and conceptualization. In this study, the vocabulary subtask was used as an index of semantic memory. In the task, participants are asked to define the meaning of a word and acquired points based on the accuracy of the definition provided. Definitions that lack abstract explanations or are overly general will be judged inaccurate and only got partial credit. Also, completely inappropriate definitions do not receive points.

Measurement of Processing Speed

Processing speed was measured in part A of the modified Trail Making Test (TMT-A; Park & Chey, 2003). In the task, participants are asked to trace numbers from 1 to 15 which were placed on a piece of paper with a pencil. It is known to measure visuospatial and motor processing speed. In this study, the time taken to

complete this task was used as an index of processing speed. The interpretation of this score is that one with the shorter time taken presents a better performance in processing speed.

Measurement of Executive Function

Digit span test (DST) and spatial span test (SST) are well-established measures of working memory. In this study, the version of the tasks in the EMS was utilized. DST is equivalent to the Numerical Range Test of the Wechsler Adult Intelligence Scale Version IV (Wechsler, 2008). In the forward trials, participants are presented with a series of numbers and asked to repeat what they have heard in the correct order. In the backward trial, participants are asked to repeat a series of numbers they have heard in reverse order. In both trials, the trial continues until the participant is unable to give a correct answer. SST incorporates the Corsi block tapping test (Kessels et al., 2000), which assesses visuospatial short-term working memory. A 27 cm x 21 cm plastic board with 10 cube blocks (3 cm x 3 cm x 3 cm) placed in an asymmetrical pattern and place an equal number of cubes on the left and right sides of the board were presented to the participants. In the forward trials, the examiner taps the blocks in a predetermined order and the contestant is asked to tap the blocks in the same order. In the backward trials, participants are asked to tap blocks in the reverse order in which they were presented by the examiner. The working memory index (ie., working memory) was based on the performance score over total number of trials and calculated as the sum of the maximum number of digits participants were able to accurately repeat on both tasks.

Working Memory Index = (DST backward span score / 8) + (SST backward span score / 8)

The Controlled Oral Word Association Test (COWAT; Kang, Jang, & Na, 2012) measures semantic fluency, a subset of verbal fluency that is relatively free from the influence of education (Ratcliff et al., 1998). In "animal" trials (COWAT-a), participants are asked to list as many animals as possible in one minute. In "store" trials (COWAT-s), participants are asked to name as many items as possible that can be purchased in a store in one minute. The total number of items produced by participants on each trial was used as an indicator for semantic fluency. The performance of this task was measured by the categorical fluency integrated score, which was estimated by obtaining the average value after converting the performance of the two subtests into standardized scores.

 Table 1. Neuropsychological measures

Function	Measures	Indices					
Episodic Memory	Elderly Memory disorder Scale	Recall index,					
		Recognition index					
Semantic Memory	K-WAIS-IV Vocabulary	Accuracy of definition					
Processing Speed	Trail-Making Test A	Time to completion					
Executive Function							
Category Fluency	COWAT (Animal, Store)	Number of items produced					
Working Memory	Elderly Memory disorder Scale	Working memory index					
K-WAIS-IV : Korean version of the Wechsler Adult Intelligence Scale 4th							
COWAT C							

COWAT : Controlled Oral Word Association Test

2.2.3. Social Network Characteristic

A social network of L- myeon and K- myeon where the research participants live was established to analyze the social relationships and lives of the participants. The module devised by Burt (1985) in the US General Social survey was co-adapted by KSHAP, and the research participants answered the question "From time to time, most people discuss things that are important to them with others. For example, these may include good or bad things that happen to you, problems you are having, or important concerns you may have. Looking back over the last 12 months, who are the people with whom you most often discussed things that were important to you?". The participants are asked to name up to five persons and a spouse (if applicable) with a possible range of 0–6 members. In this social network size, people residing outside the village were not included. Through social networks, it is possible to grasp the interaction between people in the whole community.

Quantitative Aspect of Social Network

The quantitative aspect of the social network was measured by the size of the individual's social network. In social network analysis, the size of a social network refers to the number of social connections an individual has and reflects the interpersonal resources an individual has (Golbeck & Klavans, 2015). When measuring the size of social networks in this study, spouses are generally included, and more than 80% (N = 147) of the study research participants were living with their spouses. Thus, we used the size of a social network consisting of up to six people, including spouses.

Another quantitative aspect of the social network was measured by the social

network density. It addresses the relationship among social network members and is measured as the proportion of all possible pairs among social network members who know each other. Social network density measures the degree of dense social networks of respondents, and people with high social network density can compare and share information, assist with caregiving tasks, or use resources (Cornwell, Schumm, Laumann, & Graber, 2009). Also, higher social network density leads to more stable and frequent access to informal help (Haines et al., 1996; Hurlbert et al., 2000). The minimum and maximum scores of social network density were 0 and 1, respectively.

Qualitative Aspect of Social Network

The qualitative aspect of the social network was measured by the emotional closeness (subjective intimacy) with each social network member participant named. Emotional closeness which is passed along via one's network involves the provision of intimacy and confiding about emotions (Cohen, 1988), thereby being likely to enhance coping strategies and increase one's sense of control over situations (King, Reis, Porter, & Norsen, 1993). Participants are asked to rate from 1 - "not very close" to 4- "extremely close" to the question, "How close do you consider your relationships with (the network member)?" The average emotional closeness level of a participant's social support network was measured by calculating the average of these values. The minimum and maximum scores of emotional closeness were 1 and 4, respectively.

In addition, social network strength measured by communication frequency was included as social network quality as well. Facilitating access to social support (Berkman & Krishna, 2014), it is an important factor in maintaining a social network in the long term and is closely related to how close one feels to their social ties (Roberts & Dunbar, 2011). Participants are asked to answer the following question, "How frequently do you have communication with (the network member)?" Possible answers are as follows: 'Less than once a year (1),' 'Once a year (2),' 'Several times in a year (3),' 'Once a month (4),' 'Once in every two weeks (5),' 'Once in every week (6),' 'Several times in a week (7),' and 'Every day (8).' The average social network strength was measured by calculating the average of these values. The minimum and maximum scores of the social network strength are 1 and 8, respectively.

2.3. Analysis

The collected data were analyzed using IBM SPSS Statistics version 26 and PROCESS macro for SPSS v.3.5 developed by Hayes (2014). Correlation with descriptive statistics of major variables was confirmed. Prior to the full-scale analysis, the validity and reliability of the Perceived Stress Scale (PSS) – 10 were tested. Reliability is a criterion for determining how consistently the measurement results are measured when repeatedly measured and validity is a criterion for determining how accurately the scale is measured. In this study, Bartlett's Test of Sphericity, which was conducted to confirm whether the data was appropriate for factor analysis, the Kaiser-Meyer-Olkin (KMO), and confirmatory factor analysis were performed. Also, in order to verify the negative effect of PSS on cognitive function independent of neuroticism and depression levels, linear regression was employed. Moreover, using the PROCESS macro model No. 4, mediation effect analysis was used to investigate whether quantitative and qualitative characteristics

of the social network significantly mediate the relationship between PSS and cognitive function through bootstrap. In addition, to investigate the relationship between subscales of PSS and cognitive function regarding social network mediation effect, mediation effect analysis for lack of perceived self-efficacy (LSE) and perceived helplessness (PH) was conducted as well. In all analyses, sex, age, years of education, marital status, and levels of neuroticism and depression that show a high correlation with PSS and cognitive function, and severity of depression measured by the Geriatric Depression Scale which also has a high correlation with PSS and cognitive function variables.

Chapter 3. Results

3.1. Descriptive Statistics on the Characteristics of Research Participants

Demographics, psychological measures, and social network characteristics measured in a total of 176 study participants are presented in Table 2. The study sample consisted of 77 (43.8%) elderly males and 99 (56.2%) older females. The average age was 72.72 years (SD:6.56) and the average years of education were 7.35 years (SD: 4.38). Of the sample, 176 (100%) had an experience of marriage, and 147 (83.5%) were currently living with their spouse. The level of neuroticism had an average score of 17.99 (SD: 5.08). Considering that the low level of neuroticism score is 10-24, the moderate level score is 25-35, and the high-level score is 36-50, there is a large number of participants reporting a low level of neuroticism. In addition, the level of depression was 9.04 on average (SD: 6.45), and considering that the cut-off point for clinical depression was 21 points (Jung et al., 1997; Spreen & Strauss, 1998), it was also found that many participants reporting a normal range of depression were included. The perceived stress level, of which the maximum is 50, was 12.75 (SD: 8.96) on average. According to Baek (2010), this score corresponds to about 47.4~52.3% of the percentile based on the Korean elderly standards. Moreover, the average total score of the MMSE-DS, out of 30 points, was 27.01 (SD: 2.17), which was the average of normal elderly people considering the age and education level of the study participants.

In terms of social network quantity, the average size of the social network,

which has a minimum value of 0 to 6, was 4.49 (SD:1.44), indicating that research participants have an average of four social relationships that can discuss important matters, and the average social network density was 0.96, implying that a large number of participants were located within a dense network. Regarding social network quality, the average emotional closeness of the participants was 3.53 within the social network, and the average social network strength was 6.89 (SD: 0.84), presenting that the participant engaged in communication with their social relations at least once a week and several times in a week.

	Range	Mean	S.D
Sex (77, males, 43.8%)			
Marital Status (living with spouse 83.5%)			
Age	[61, 93]	72.72	6.56
Education	[0, 23]	7.35	4.38
Neuroticism	[8, 29]	17.99	5.08
Depression	[0, 29]	9.04	6.45
Perceived Stress	[0, 35]	12.75	8.96
Lack of Self-Efficacy	[0, 20]	6.11	4.72
Perceived Helplessness	[0, 26]	7.64	6.00
Social Network Size	[1, 6]	4.49	1.44
Social Network Density	[0.33, 1.00]	0.96	0.12
Emotional Closeness	[2, 4]	3.53	0.47
Social Network Strength	[4.67, 8.00]	6.89	0.84
Number of Open Ties	[0, 10]	0.55	1.56
MMSE-DS	[20, 30]	27.01	2.17

 Table 2. Participant information

3.2. Correlation between Main Variables

The results of analyzing the correlation between the main variables are

presented in Table 3. In terms of sex, elderly males had higher education (r=0.403, p<0.01) and were more likely to live with a spouse (r=0.299, p<0.001). They performed better in various cognitive functions and subtasks including global cognition (r=0.220, p<0.01), executive function (r=0.271, p<0.01), semantic memory (r=0.286, p<0.01), processing speed (r=-0.156, p<0.05), and working memory index (r=0.378, p<0.01) in executive function.

In addition, age was negatively correlated with social network characteristics. Older people had a smaller social network size (r=-0.230, p<0.01) and a lower social network density (r=-0.243, p<0.01). They also showed poor performance in global cognition (r=-0.377, p<0.01), episodic memory (r=-0.419, p<0.01), executive function (r=-0.251, p<0.01), and semantic memory (r=-0.194, p<0.01), in processing speed (r=0.341, p<0.01). For each test of the episodic memory, there were negative correlations with the recall index (r=-0.281, p<0.001). As age increases, social network size decreases and the decline in cognitive function becomes more common in late life.

Years of education are negatively correlated with the Perceived Stress Scale (PSS) (r=-0.232, p<0.001), lack of perceived self-efficacy (LSE) (r=-0.202, p<0.001), perceived helplessness (PH) (r=-0.187, p<0.001), and every domain and test of cognitive function, and it showed a positive correlation with social network size (r=0.162, p<0.01). PSS and LSE showed significant associations with every domain and test of cognitive function. Individuals with higher levels of PSS performed worse in global cognition (r=-0.319, p<0.01), episodic memory (r=-0.255, p<0.01), recall index (r=-0.209, p<0.01), recognition index (r=-0.272, p<0.01), executive function (r=-0.265, p<0.01), working memory (r=-0.150, p<0.05), category fluency (r=-0.296, p<-0.296, p<-0.296).

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. SEX	1																					
2. AGE	.176*	1																				
3. EDUCATION	.403**	056	1																			
4. MARITAL STATUS	.299**	274**	.233**	1																		
5. NEUROTICISM	120	119	141	.050	1																	
6. DEPRESSION	064	.085	255**	.031	.494**	1																
7. PERCEIVED STRESS	066	.041	232**	.056	.523**	.740**	1															
8. LACK OF PERCEIVED SELF-EFFICACY	028	.076	202**	.066	.412**	.572**	.786**	1														
9. PERCEIVED HELPLESSNESS	077	.001	187*	.032	.456**	.654**	.874**	.386**	1													
10. SOCIAL NETWORK SIZE	.107	230***	.162*	.300**	097	013	.019	013	.038	1												
11. SOCIAL NETWORK DENSITY	.037	.243**	126	.013	.121	.235**	.197**	.167*	.162*	216**	1											
12. EMOTIONAL CLOSENESS	.037	.058	.141	.001	162*	107	221**	186*	184*	.028	.133	1										
13. SOCIAL RELATIONSHIP STRENGTH	094	.005	105	100	018	175*	132	095	123	280**	.102	054	1									
14. GLOBAL COGNITION	.220**	391**	.610**	.150*	160*	361**	319**	315**	229**	.207**	218**	.086	040	1								
15. EPISODIC MEMORY	020	419**	.399**	.121	128	286**	255***	246**	188*	.165*	158*	.157*	006	.780**	1							
16. RECALL INDEX	049	377**	.328**	.100	119	248**	209**	218**	141	.160*	147	.190*	064	.704**	.941**	1						
17. RECOGNITION INDEX	.011	412**	.423**	.127	121	291**	272**	245**	213**	.151*	150	.106	.052	.764**	.941**	.773**	1					
18. EXECUTIVE FUNCTION	.271**	251**	.483**	.146	166*	266**	265**	288**	168*	.195**	191*	.034	032	.807**	.541**	.478**	.540**	1				
19. WORKING MEMORY	.378**	142	.457**	.163*	164*	182*	150*	178*	085	.131	088	.049	.001	.677**	.456**	.406**	.454**	.849**	1			
20. CATEGORY FLUENCY	.048	281**	.331**	.072	107	261**	296**	306**	201**	.195**	233**	.004	058	.652**	.435**	.382**	.436**	.797**	.357**	1		
21. SEMANTIC MEMORY	.286**	194**	.647**	.169*	198**	346**	315**	297**	236**	.157*	183*	.124	110	.809**	.530**	.468**	.530**	.600**	.507**	.481**	1	
22. PROCESSING SPEED	156*	.341**	358**	033	.014	.216**	.157*	.152*	.115	132	.146	.050	025	706**	350**	298**	361**	435**	351**	368**	361**	1

*. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

p<0.01), semantic memory (r=-0.315, p<0.01), and in processing speed (r=0.157, p<0.05). Similarly, the LSE presented the same pattern as the PSS. People having a lower degree of self-efficacy showed poor performance in global cognition (r=-0.315, p<0.01), episodic memory (r=-0.246, p<0.01), recall index (r=-0.218, p<0.01), recognition index (r=-0.245, p<0.01), executive function (r=-0.288, p<0.01), working memory (r=-0.178, p<0.05), category fluency (r=-0.306, p<0.01), semantic memory (r=-0.297, p<0.01), and in processing speed (r=0.152, p<0.05). However, PH was negatively correlated with cognitive function except for recall index, working memory, and processing speed. PH presented negative correlations with global cognition (r=-0.213, p<0.01), episodic memory (r=-0.168, p<0.05), category fluency (r=-0.168, p<0.05), category fluency (r=-0.201, p<0.01), and semantic memory (r=-0.26, p<0.01). Overall, these results support the previous study that PSS level and cognitive function have a negative correlation (Baek 2010; Korten et al., 2016; Chen et al., 2019).

In terms of social network quantity, social network size did not present any significant associations with the PSS, LSE, and PH. However, social network size had positive correlations with global cognition (r=0.207, p<0.01), episodic memory (r=0.165, p<0.05), recall index (r=0.160, p<0.05), recognition index (r=0.151, p<0.05), executive function (r=0.195, p<0.01), category fluency (r=0.195, p<0.01), and semantic memory (r=0.157, p<0.05). Social network density presented positive correlations with the PSS (r=0.197, p<0.01), LSE (r=0.167, p<0.05), and PH (r=0.162, p<0.05). It also had negative correlations with global cognition (r=-0.218, p<0.01), episodic memory (r=-0.158, p<0.05), executive function (r=-0.191, p<0.05),

category fluency (r=-0.233, p<0.01), and semantic memory (r=-0.183, p<0.05). In terms of social network quality, emotional closeness had negative correlations with PSS (r=-0.221, p<0.01), LSE (r=-0.186, p<0.05), and PH (r=-0.184, p<0.05). It also had a positive correlation with episodic memory (r=0.157, p<0.05), and recall index (r=0.190, p<0.05). However, social network strength did not present any associations with PSS, LSE, and PH, and any cognitive function. In general, people with a larger social network size, lower social network density, and a higher degree of emotional closeness presented a better performance in cognitive function.

In addition, the PSS level and its two subscales presented results consistent with previous studies that reported a positive correlation with neuroticism level (Jiang, Seng, Zimmerman, Kim, & Lipto, 2017) and depression level (Cristóbal-Narváez, Haro, & Koyanagi, 2022; Lee, Joo, & Choi, 2013). PSS was positively correlated with neuroticism (r=0.523, p<0.01) and depression (r=0.740, p<0.01). LSE was positively correlated with neuroticism (r=0.412, p<0.01) and depression (r=0.572, p<0.01). PH was positively correlated with neuroticism (r=0.456, p<0.01) and depression (r=0.456, p<0.01) and depression (r=0.654, p<0.01).

3.3. Reliability and Validity of Perceived Stress Scale - 10

The Bartlett's Test of Sphericity was significant (p<0.001), and as the result of the Kaiser-Meyer-Olkin (KMO) test, it was found to be 0.80, which is higher than 0.6, indicating appropriateness, and confirming that it is reasonable to proceed with factor analysis. In addition, the result of confirmatory factor analysis with the varimax rotation method presented that factors with an eigenvalue exceeding 1 were found to be two factors, and the total explanatory variance was 56.142%. As

Table 4. Confirmatory factor analysis of PSS - 10

Number	Item	Factor 1	Factor 2
1	In the last month, how often have you been upset because of something that happened unexpectedly?	<u>0.81</u>	0.03
2	In the last month, how often have you felt that you were unable to control the important things in your life?	<u>0.56</u>	-0.31
3	In the last month, how often have you felt nervous and stressed?	<u>0.83</u>	0.00
4	In the last month, how often have you felt confident about your ability to handle your personal problems?	-0.04	<u>0.84</u>
5	In the last month, how often have you felt that things were going your way?	-0.43	<u>0.69</u>
6	In the last month, how often have you found that you could not cope with all the things that you had to do?	<u>0.51</u>	-0.27
7	In the last month, how often have you been able to control irritations in your life?	-0.03	<u>0.62</u>
8	In the last month, how often have you felt that you were on top of things?	-0.14	<u>0.80</u>
9	In the last month, how often have you been angered because of things that happened that were outside of your control?	<u>0.84</u>	-0.04
10	In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?	<u>0.56</u>	-0.30

presented in Table 4, items with a high load factor for factor 1 were items 1, 2, 3, 6, 9, and 10, which were related to negative experiences among stress-related experiences. In previous studies, this factor was revealed as "perceived helplessness," and in this research, this factor explained 31.44% of the total variance. Moreover, the items with a high factor load for factor 2 were items 4, 5, 7, and 8, which were composed of items related to whether they were able to cope with the immediate problems and felt a sense of control during stress-related experiences. It was confirmed that factor 2 was named as "lack of perceived self-efficacy" when it comes to the reversely coded score for total PSS score, and this factor explained 24.70% of the total variance.

3.4. Effect of Perceived Stress on Cognitive Function

In order to confirm the first hypothesis of this study, the effect of perceived stress on cognitive function was investigated. Table 5 shows the results from the linear regression analyses between perceived stress and the different cognitive outcome measures. When adjusting for demographics, such as age, sex, years of education, and marital status, perceived stress was negatively associated with global cognition, episodic memory, executive function, and semantic memory. Within the episodic memory and executive function, perceived stress showed negative associations with recognition index and category fluency. However, additional adjustment of neuroticism level made the associations with global cognition, episodic memory, and executive function nonsignificant. Only the associations with worse semantic memory of cognitive function domains and poor category fluency performance of executive function remained significant. Additional adjustment for depression level revealed only a significant association with poor category fluency performance within the executive function.

Table 5. Regression results

5-1. Regression	results of	stress	and	cognitive	function	domains

	Glo Cogn	bal ition	Epis Men	odic nory	Exect Func	utive tion	Semantic Memory		Proce Spe	ssing eed
	β	р	β	р	β	р	β	р	β	р
Perceived stress ¹	-0.167	0.002	-0.154	0.017	-0.152	0.021	-0.168	0.004	0.049	0.472
Perceived stress ²	-0.145	0.052	-0.118	0.116	-0.120	0.117	-0.139	0.041	0.075	0.347
Perceived stress ³	-0.066	0.410	-0.062	0.520	-0.098	0.317	-0.066	0.441	-0.010	0.923

¹Adjusted for age, sex, years of education, and marital status.

²Additionally adjusted for neuroticism level.

³Additionally adjusted for depression level.

5-2. Regression results of stress and subtests of episodic memory and executive function

Cognitive Domain		Episodic	Memory		Executive Function					
	Rec	Recall Recognition			Wor	king	Category			
Subtest	Ind	ex	Ind	lex	Men	nory	Fluency			
	β	р	β	р	β	р	β	р		
Perceived stress ¹	-0.124	0.070	-0.166	0.010	-0.044	0.513	-0.218	0.002		
Perceived stress ²	-0.079	0.320	-0.143	0.056	0.015	0.852	-0.229	0.006		
Perceived stress ³	-0.021	0.837	-0.095	0.317	0.039	0.695	-0.218	0.039		

¹Adjusted for age, sex, years of education, and marital status.

²Additionally adjusted for neuroticism level.

³Additionally adjusted for depression level.

3.5. Mediation Effect of Social Network Quantity and Quality on the Relationship between Perceived Stress and Cognitive Function

To verify the second hypothesis of this study, we explored whether quantitative and qualitative aspects of social networks mediate the relationships between perceived stress and cognitive function. The mediation effects of social network quantity measured by social network size and social network density and social network quality measured by emotional closeness and social network strength on the relationship between perceived stress and cognitive functions of all cognitive function domains and subtests were verified. In this analysis, age, sex, years of education, marital status, neuroticism, and depression were controlled. To investigate the mediation effect, bootstrapping was performed using the PROCESS macro model No. 4, and the number of bootstrapping samples was 5,000. The results are presented in Tables 6 and 7, and Figure 2.

As a result of mediation analysis, no association was found between Perceived Stress Scale (PSS) and cognitive function, nor was there any association with social network quantity measured with social network size and social network density. In other words, no relationship was found among the participants in this study between PSS level, social network quantity, and cognitive function. Yet, in terms of social network quality, there was a significant mediation effect. While social network strength of social network quality did not show any significant mediation effect, the emotional closeness of social network quality significantly mediated the associations between PSS and the recall index of episodic memory. Since this study assumed a single direction in bootstrapping, when the lower limit confidence interval (LLCI) and the upper limit confidence interval (ULCI) of the mediation effect coefficient for each cognitive task performance were obtained in a 95% confidence interval, the mediation effect can be considered statistically significant only when 0 is not included in the confidence interval of the two values. According to Table 7-1, the confidence interval of the upper and lower limits of the mediation effect coefficient of emotional closeness did not include 0. This can be interpreted that the levels of PSS can affect the recall index of episodic memory by mediating emotional closeness, which refers to social network quality.

In addition, since PSS has two different subscales, the mediation effects of emotional closeness on the relationship between lack of perceived self-efficacy (LSE) and perceived helplessness (PH), and cognitive function were explored as well. The results are presented in Table 8 and Figures 3 - 4. Between LSE and PH, only LSE had a significant mediation effect of emotional closeness which is one aspect of social network quality (see Table 8 - 1). Therefore, according to the results of this study, levels of PSS and LSE were completely mediated by social network quality measured by emotional closeness, influencing recall index in episodic memory.

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	0.029 (0.306)	-0.006 (0.366)	0.001	-0.0010	0.0027
	Episodic Memory	0.024 (0.589)	-0.007 (0.494)	0.000	-0.0019	0.0034
0.018 (0.301)	Recall Index	0.016 (0.493)	-0.001 (0.795)	0.000	-0.0009	0.0019
	Recognition Index	0.004 (0.772)	-0.003 (0.309)	0.000	-0.0006	0.0009
	Executive Function	0.042 (0.255)	-0.009 (0.276)	0.001	-0.0013	0.0039
	Working Memory	0.001 (0.937)	0.001 (0.702)	0.000	-0.0006	0.0008
	Category Fluency	0.080 (0.073)	-0.023 (0.027)	0.002	-0.0016	0.0062
	Semantic Memory	0.189 (0.687)	-0.087 (0.424)	0.004	-0.0225	0.0345
	Processing Speed	-0.587 (0.511)	-0.009 (0.965)	-0.011	-0.0712	0.0283

Table 6. The mediation effect of social network quantity in the relationship between PSS level and cognitive function**Table 6-1.** Mediation effect of social network size on the relation between PSS and cognitive function

Table 6-2. Mediation effect of social network density on the relation between PSS and cognitive function

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	-0.101 (0.760)	-0.004 (0.549)	0.000	-0.0006	0.0016
	Episodic Memory	0.251 (0.625)	-0.004 (0.675)	0.000	-0.0007	0.0027
	Recall Index	0.073 (0.789)	-0.000 (0.966)	0.000	-0.0003	0.0013
	Recognition Index	0.092 (0.522)	-0.002 (0.453)	0.000	-0.0002	0.0007
0.000 (0.798)	Executive Function	-0.382 (0.371)	-0.007 (0.434)	0.000	-0.0018	0.0015
	Working Memory	-0.004 (0.977)	0.001 (0.663)	0.000	-0.0002	0.0006
	Category Fluency	-0.748 (0.151)	-0.019 (0.078)	0.000	-0.0039	0.0019
	Semantic Memory	-2.961 (0.586)	-0.086 (0.438)	-0.001	-0.0130	0.0357
	Processing Speed	0.127 (0.990)	-0.0504 (0.811)	0.000	-0.0328	0.0156

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	0.001 (0.989)	-0.005 (0.420)	0.000	-0.0029	0.0025
	Episodic Memory	0.212 (0.101)	-0.003 (0.735)	-0.003	-0.0090	0.0006
	Recall Index	0.154 (0.024)	0.001 (0.834)	-0.002	-0.0058	-0.0001
	Recognition Index	0.025 (0.493)	-0.003 (0.391)	0.000	-0.0017	0.0007
-0.014 (0.018)	Executive Function	-0.077 (0.481)	-0.010 (0.267)	0.001	-0.0024	0.0050
	Working Memory	-0.004 (0.894)	0.001 (0.719)	0.000	-0.0011	0.0012
	Category Fluency	-0.134 (0.311)	-0.023 (0.027)	0.002	-0.0020	0.0068
	Semantic Memory	0.497 (0.721)	-0.076 (0.489)	-0.007	-0.0532	0.0355
	Processing Speed	3.167 (0.231)	0.026 (0.903)	-0.045	-0.1490	0.0247

Table 7. The mediation effect of social network quality in the relationship between PSS level and cognitive function**7-1.** Mediation effect of emotional closeness on the relation between PSS and cognitive function

7-2. Mediation effect of social network strength on the relation between PSS and cognitive function

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	-0.015 (0.754)	-0.005 (0.405)	0.000	-0.0009	0.0017
	Episodic Memory	-0.003 (0.965)	-0.007 (0.520)	0.000	-0.0017	0.0024
	Recall Index	-0.037 (0.326)	-0.001 (0.811)	0.000	-0.0018	0.0019
	Recognition Index	0.020 (0.332)	-0.003 (0.334)	0.000	-0.0008	0.0006
-0.005 (0.652)	Executive Function	-0.001 (0.981)	-0.009 (0.318)	0.000	-0.0015	0.0018
	Working Memory	0.016 (0.385)	0.001 (0.674)	0.000	-0.0007	0.0005
	Category Fluency	-0.073 (0.323)	-0.022 (0.036)	0.000	-0.0017	0.0030
	Semantic Memory	-1.078 (0.162)	-0.088 (0.411)	0.005	-0.0173	0.0452
	Processing Speed	-0.776 (0.597)	-0.024 (0.908)	0.004	-0.0282	0.0426

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	-0.002 (0.985)	-0.014 (0.159)	0.000	-0.0034	0.0029
	Episodic Memory	0.211 (0.100)	-0.009 (0.576)	-0.003	-0.0116	0.0011
	Recall Index	0.148 (0.028)	-0.003 (0.686)	-0.002	-0.0073	-0.0006
	Recognition Index	0.028 (0.442)	-0.003 (0.532)	0.000	-0.0024	0.0007
-0.016 (0.045)	Executive Function	-0.082 (0.442)	-0.026 (0.046)	0.001	-0.0027	0.0064
	Working Memory	-0.010 (0.766)	-0.003 (0.451)	0.000	-0.0013	0.0013
	Category Fluency	-0.122 (0.351)	-0.039 (0.015)	0.002	-0.0023	0.0089
	Semantic Memory	0.461 (0.738)	-0.199 (0.233)	-0.007	-0.0622	0.0436
	Processing Speed	3.183 (0.224)	0.070 (0.825)	-0.050	-0.1787	0.0396

Table 8. The mediation effect of emotional closeness in the relationship between LSE and PH levels and cognitive function **8-1.** Mediation effect of emotional closeness on the relation between LSE and cognitive function

8-2. Mediation effect of emotional closeness on the relation between PH and cognitive function

$\begin{array}{c} X \to M \\ (a) \end{array}$	Outcome (Y)	$\begin{array}{c} M \rightarrow Y \\ (b) \end{array}$	Direct Effect (c)	Indirect Effect (c')	Indirect Effect LLCI	Indirect Effect ULCI
	Global Cognition	0.015 (0.0856)	0.001 (0.877)	0.000	-0.0031	0.0027
	Episodic Memory	0.221 (0.089)	0.001 (0.970)	-0.003	-0.0086	0.0008
-0.013 (0.099)	Recall Index	0.157 (0.020)	0.004 (0.540)	-0.002	-0.0058	0.0002
	Recognition Index	0.028 (0.438)	-0.002 (0.565)	0.000	-0.0016	0.0008
	Executive Function	-0.051 (0.636)	0.003 (0.801)	0.001	-0.0026	0.0048
	Working Memory	-0.002 (0.952)	0.004 (0.269)	0.000	-0.0009	0.0012
	Category Fluency	-0.094 (0.479)	-0.011 (0.435)	0.001	-0.0029	0.0060
	Semantic Memory	0.693 (0.616)	0.017 (0.906)	-0.009	-0.0566	0.0289
	Processing Speed	3.099 (0.237)	-0.008 (0.977)	-0.040	-0.1592	0.0264





Figure 2. Mediation effect of emotional closeness on the association between perceived stress total score (PSS) and recall Index.

Figure 3. Mediation effect of emotional closeness on the association between lack of perceived self-efficacy score (LSE) and recall Index.



Figure 4. Mediation effect of emotional closeness on the association between perceived helplessness score (PSS) and recall Index.

Chapter 4. Discussion

The current study investigated whether social network quantity and quality characteristics mediate stress-related cognitive deficits and explored whether these mediation effects are independent of neuroticism and depression levels in normal older adults. Our findings presented that perceived stress had a negative effect on category fluency in executive function. Moreover, in the result of the mediation analysis, the emotional closeness of social network quality significantly explained the relationship between perceived stress and the recall index of episodic memory. However, social network quantity measured by social network size and social network density did not reveal any significant mediation effects on effects on the association between perceived stress may be a crucial factor in explaining the association between perceived stress and cognitive function.

4.1. Effect of Perceived Stress on Cognitive Function

It was observed that higher levels of perceived stress were associated with category fluency within the executive function. This result is in line with previous studies in older adults (Korten et al., 2016; Rimmele, Ballhausen, Ihle, & Kliegel, 2022; Jiang, Seng, Zimmerman, Kim, & Lipto, 2017). Although another study did not observe a negative association with category fluency (Feeney, O'Sullivan, Kenny, & Robertson, 2018), it may be attributable to using only one category, "animals". Employing different categories such as "animals' and "store" in category fluency,

perceived stress is associated with poor semantic fluency. In addition, despite losing significant associations by additional adjustment of neuroticism and depression levels, the negative effect of perceived stress on cognitive function was confirmed through the three different models.

4.2. Mediation Effect of Social Network Quantity in the Relationship between Perceived Stress and Cognitive Function

In this study, social network quantity measured by social network size did not mediate the relationship between the Perceived Stress Scale (PSS), Lack of Perceived Self-Efficacy (LSE), and Perceived Helplessness (PH), and cognitive function. A larger social network quantity is thought to provide regular positive experiences and a set of stable, socially rewarded roles in the community, and socially integrated people may avoid negative experiences such as economic or legal problems. In this view, social network quantity can be considered as status support (Cohen & Wills, 1985).

However, the quantitative aspect of the social network provides only a very indirect indicator of the availability of social support functions. The reason is that it assesses only the existence or relationship numbers and does not provide sensitive measures of the functions or quality actually provided by those relationships. In addition, the number of social connections has been reported low correlations between 0.20 and 0.30 with social support (Barrera, 1981; Cohen et al., 1982; Sarason, Levine, Basham, & Sarason, 1983). In this study, the correlations between social network quantity measures and social network quality measures were low (r=0.028, between social network size and emotional closeness), or there was a

negative correlation between social network size and social network strength (r=-0.280, p<0.001). That is, an adequate social support function can be derived from one very good relationship rather than the size of the social network, and may not be available to those with multiple superficial relationships. Yet, since this study only included discussion members who are living in the same village, social network size may not be able to grasp the study participants' true social network ties. Without such restriction, social network size which is consisted of confidants would be able to explain the relationship between perceived stress and cognitive function.

4.3. Mediation Effect of Social Network Quality on the Relationship between Perceived Stress and Cognitive Function

4.3.1. Mediation Effect of Emotional Closeness

Unlike social network quantity, social network quality measured by emotional closeness was found to completely mediate the relationship between perceived stress and long-term memory recall index independent of neuroticism and depression levels. Among the domains of various cognitive functions, emotional closeness mediated the relationship between perceived stress and the recall index of episodic memory. Episodic memory is a memory system involved in the storage and recall of personal experiences and information temporally and spatially related to those experiences. The ability to remember the events of daily life and recall the information in necessary situations can be seen as very important in carrying out daily life. Episodic memory function is reported to be the most greatly diminished with aging among long-term memories. Semantic memory rises until about age 60 and then declines, whereas episodic memory rapidly declines around age 60 (Nyberg

et al., 2012; Rönnlund, Nyberg, Bäckman, & Nilsson, 2005; Salthouse, 2019). In addition, since episodic memory function in late life has predictive power for instrumental daily living performance (Overdrop et al., 2016), maintenance of episodic memory function can be seen as having great implications for maintaining independence in daily life and leading an adaptive life in old age.

The results of this study showed that within the episodic memory, emotional closeness and recall index were more closely related than the social network quantity in late life. Also, the level of perceived stress had a negative association with the quality of the social network and had an indirect negative correlation with cognitive function. In other words, within such episodic memory, which is important in late life's independence, social network quality appeared to mediate the effect of perceived stress in the recall index, and no mediation effect was found in the recognition index.

According to previous studies, free recall tasks in which information must be retrieved by oneself without clues require more cognitive resources than recognition based on familiarity, and in the normal aging process, recall ability appears to be markedly reduced compared to recognition ability (Danckert & Craik, 2013). Therefore, there is a possibility that the quality of the social network in the recognition task, which requires relatively few cognitive resources, did not mediate the relationship between perceived stresses. Moreover, the recall index is an index of various aspects of episodic long-term memory ability and reflects the function of the medial temporal lobe centered on the hippocampus (Chey et al., 2006). In other words, a high level of stress perception can be interpreted as having a negative effect on long-term memory function, and it can be considered as a behavioral result that

is in line with the study of Gianaros and colleagues (2007), which reported a decrease in hippocampal volume due to stress. However, since the mechanism of the relationship between the quality of social networks and performance on recall and recognition tasks is not clear, care must be taken in interpretation, which needs to be confirmed through follow-up studies.

In addition, the quality of social networks in late life showed a positive correlation with cognitive function. This can be interpreted by the "Social Bonding Hypothesis". The social bonding hypothesis proposes that the positive function of social engagement is derived from close and supportive connections with others (Berkman & Glass, 2000). Social cohesion takes the form of integration, collaboration, meaningful social roles, and emotional support as a result of being embedded in relationships and small groups (Thoits, 2011). Individuals who are rich in social cohesion benefit from a strong and comfortable social safety net that is typically built on the context of close relationships with others. Social bonding promotes a sense of life and belonging, and fosters a sense of security that promotes safety, as well as self-esteem and control, which can help maintain health and cognitive function (Cohen, 2004; Thoits, 2011).

4.3.1.1. Mediation Effect of Emotional Closeness on the Relationship between PSS subscales and Cognitive Function

The mediation effect of emotional closeness on the relationship between subscales of Perceived Stress Scale (PSS), Lack of Perceived Self-Efficacy (LSE) and Perceived Helplessness (PH), and cognitive function was significant only in LSE. Recently Korten and colleagues (2016) reported that not only PSS total score but also the subscales of PSS, LSE and PH, were negatively related to cognitive function in non-demented older adults. Between the two subscales, LSE was more closely related to cognitive function in late life than PH. Similarly, one other study found that LSE was correlated better with cognitive function while PH was not related to cognitive function when it comes to the adjustment of depressive symptoms (Jiang, Seng, Zimmerman, Kim, & Lipto, 2017). With the results of previous studies and the current study, LSE seems to be more closely related to cognitive function in late life, and such relationship can be explained by emotional closeness.

4.3.2. Mediation Effect of Social Network Strength

The mediation analysis of social network strength in social network quality on the relationship between perceived stress and cognitive function was not significant. At first, social network strength, measured by communication frequency, was predicted to have a positive mental health outcome by connecting with others through communication and fulfilling a need for affiliation. However, in this study, the qualitative aspect of communication and its effects as social network strength were difficult to be observed.

4.4. Significance and Limitations of the Study

The significance of this study is as follows. First, by additional adjustment of neuroticism and depression levels, this study was able to clarify the relationship between perceived stress and cognitive function. Since neuroticism and depression levels are strongly associated with perceived stress and cognitive performance, our findings focused on the effects of perceived stress on cognitive function and these results may guide future studies to include two different variables as covariates.

Also, by introducing social network characteristics into the relationship between perceived stress and cognitive function, the relationship between perceived stress and social network quantity and quality was clarified, suggesting that quality, especially emotional closeness, is more closely related to cognitive function in late life than quantity. This result also supports the previous study, which found that social quality has a greater importance than quality in terms of mental health among older adults (Fiori, Antonucci, & Cortina, 2006).

In addition, the proposal of the mediation effect may have significance in terms of intervention. This study implies the importance of emotional closeness as a modifiable risk that can give a negative impact on cognitive function in late life. Therefore, older adults should be able to obtain emotional support through active exchanges in order to prevent the higher level of perceived stress from leading to problems in cognitive function. This suggests that a societal policy direction is needed to help achieve this goal.

Lastly, the mediation effect of social network quality rather than the moderation effect can give an insight into the relationship between perceived stress and social network quality, especially social support. Many literatures have reported that social support operates as a buffer and alleviates stress perception (ie., stress-buffering effect). Social support itself is also known to be related to overall well-being as it provides positive affect, a sense of predictability, stability in one's life situation, and a recognition of self-worth. However, the result that social support has a mediating effect rather than a moderating effect can be interpreted as follows. Based on the nature of stress, having already a high level of perceived stress is thought to mean that an appropriate response and coping response cannot be immediately made to what is perceived as a threat (Selles, 1970). Therefore, it seems that a high perceived stress level mediates a low level of perceived social support, and negatively affects cognitive function.

Despite the above significance, this study has some limitations, and these points should be thoroughly investigated in future studies. As this study is a cross-sectional study, the causal relationship between perceived stress and the quality of the social network is not clear. In other words, it is not clear whether the quality of the social network decreased because the level of perceived stress was high, or the perceived stress level increased because the quality of the social network was low. Further longitudinal studies need to clarify which of high levels of perceived stress and low amounts of social network precede it.

Moreover, due to the characteristics of the research participants, the generalizability of the research results is partially limited. This study was based on the Korean healthy older adults living in rural communities. In rural areas, there are fewer opportunities for social participation due to insufficient facilities for providing official social services such as welfare centers, sports facilities, and senior colleges (Park, Park, & Yeom, 2015), which can affect social network quantity and quality. In addition, compare to those living in the urban area, there are more family structures in the form of elderly couples or living alone. It seems more difficult to receive emotional and instrumental support from their children due to urbanization and being far away from their children (Kim & Lee, 2012). Therefore, in future studies, it is necessary to re-verify the results of this study, including the older adults living in cities.

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Korean Abstract

한국 노인의 지각된 스트레스가 인지기능에 미치는 영향: 정서적 유대감의 매개효과

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임상심리 전공

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노년기는 스트레스원이 증가하는 시기이며, 개인의 지각된 스트레스는 노년기 인지저하의 대표적인 위험요인으로 알려져 있다. 또한, 선행연구들에 따르면 지각된 스트레스는 개인의 사회연결망의 질적, 양적인 특성과도 부적 상관관계를 가진다. 그러나 현재까지 지각된 스트레스와 노년기 인지기능, 그리고 사회연결망의 특성 간의 관계를 탐색한 연구는 부재하다. 더 나아가 기존의 연구들에서는 지각된 스트레스와 관련성이 매우 높은 신경증 및 우울 수준을 통제하지 않았다는 한계점이 존재한다. 이러한 한계점을 바탕으로 본 연구에서는 지각된 스트레스와 인지기능의 관계에서 사회연결망의 질적, 양적 속성이 매개효과를 가지는지 살펴보았다. 본 분석은 신경증과 우울수준을 통제한 상태에서 진행되었다. 한국인의 사회적 삶, 건강과 노화에 대한 조사 (KSHAP)에 참여한 60세 이상 지역사회 거주 노인 176명을 대상으로 지각된 스트레스, 심리설문, 사회연결망 조사 및 신경심리검사를 실시하였다. 그 결과 지각된 스트레스는 집행기능 중

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범주 유창성에 부정적 영향을 미치는 것으로 나타났다. 매개분석 결과, 사회연결망의 질적 측면을 나타내는 정서적 유대감은 지각된 스트레스와 장기기억지수와의 관계를 완전매개하였다. 더 나아가 지각된 스트레스의 두 가지 하위요인인 지각된 자기효능감의 결여와 지각된 무기력감 중 어떤 요인이 노년기 인지기능과 사회연결망간의 관계에 있어 더 큰 영향을 미치는지 추가분석을 통해 살펴보았다. 그 결과, 두 하위척도 중, 정서적 유대감의 매개효과는 지각된 자기효능감의 결여와 장기기억지수의 관계에서만 유의하였다. 이러한 결과는 사회연결망의 질적인 측면, 특히 정서적 유대감이 지각된 스트레스와 인지기능과의 관계를 설명하는 기전임을 시사하며, 특히 지각된 스트레스 중 자기효능감의 결여가 노년기 인지기능에 있어 중요한 요인임을 알 수 있다.

주요어: 지각된 스트레스, 지각된 자기효능감의 결여, 노년기 인지기능, 사회관계망의 양, 사회관계망의 질, 정서적 유대감 **학 번:** 2019-23600

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