



The Role of Executive Functions in the Relationship Between Loneliness and Psychological Well-Being of the Elderly

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Abstract

Background: Perceived loneliness has insinuation in both cognitive and well-being of individuals. Loneliness is a major risk factor for depressive disorder. Decreased executive function is a significant problem for older adults that plays an essential role in their psychological well-being.

Objectives: This study aimed to investigate the role of executive functions in the loneliness and psychological well-being of the elderly.

Methods: The present correlational study with a survey research design used structural equation modeling. The sample size was 115 people selected using purposeful sampling. The Ryff's psychological well-being questionnaire, executive function tests (including N-Back, Trail Making Test, quantitative calculations, London Tower, and Reaction Time), and the DiTomaso Social and Emotional Loneliness Scale for Adults were used to collect information required for this research.

Results: Model fit indices showed that the conceptual model extracted based on theoretical foundations had an acceptable fit (RMSEA = 0.047). The analysis results showed that executive functions played a mediating role in the relationship between perceived loneliness and psychological well-being. The perceived loneliness showed a significant inverse relationship with executive functions and psychological well-being, but executive functions had a direct relationship with psychological well-being.

Conclusions: In the present study, it was found that executive functions played a mediating role in the relationship between psychological well-being and the perceived loneliness of the elderly, and these findings are consistent with previous research and theoretical foundations. Further research is suggested to determine biological mechanisms underlying the relationship between perceived loneliness and executive functions with psychological well-being.

Keywords: Aged, Cognition, Executive Function, Loneliness, Quality of Life

1. Background

The dramatic increase in the elderly population worldwide and in Iran raises the importance of the elderly in our society and reveals the need for research in this field. According to the general census of 2011, the elderly population over 60 years of age in Iran was about 6,159,676 people (8.23%). This population is predicted to reach more than 25 million by 2050, a faster trend than other age groups (1). Loneliness is a significant concern among the elderly, especially in societies with a rapidly growing elderly population (2). By aging, the likelihood of loneliness due to the death of loved ones and the loss of friends increases (3), and a series of studies have shown that loneliness is associated with reduced psychological well-being and quality of

life in the elderly (4). Ryff and Keyes noted that psychological well-being consists of five factors. These factors include self-acceptance, positive relationships with others, autonomy, purpose in life, and personal growth (5). Psychological well-being is influenced by challenging and rewarding life events (6). However, several studies have shown that living alone is not associated with reduced quality of life and psychological well-being (7), and more recent studies have shown that what matters is the feeling of loneliness or perceived loneliness (8). Feeling lonely is defined as a person's mental experience concerning the lack of satisfactory human relationships (9). Feelings of loneliness are evoked when one has no social partners, does not feel emotional intimacy with anyone, feels that they are a stranger to others, and no one understands them, or they are rejected by

others (10).

Primary evidence suggests that loneliness is associated with reduced cognitive functions (2). Cognitive decline, in turn, has a negative effect on the ability to perform day-to-day tasks and maintain the functional independence (i.e., financing, food provision, transportation, and supply purchase) of the elderly. The progression of cognitive decline leads to dementia and Alzheimer's, which are not natural consequences of aging because the aging brain still retains neurogenesis abilities and neural flexibility (11). Cognitive deficits lead to reduced quality of life among the elderly, an additional burden on caregivers, and economic costs to the medical system (12). Therefore, gaining more understanding of psychological phenomena related to the reduction of executive functions is critical to prevent cognitive decline and improve the quality of life of the elderly (11).

Evidence suggests that maintaining cognitive functions is associated with a healthier lifestyle and greater well-being (13). However, most recent research has focused only on improving executive functions (14) and ignored perceived emotional experience or well-being. For this reason, the effects of cognitive abilities are not very clear on well-being. It is believed that increasing cognitive abilities positively affects well-being (15), but this relationship is hypothetical and has no research evidence. For this reason, one of the issues that was addressed in this article was the relationship between executive functions and the well-being of the elderly.

2. Methods

This research was applied in terms of purpose and used structural equation modeling. The statistical population of the study included all vital elderly who were referred to retirement centers in Tehran in 2018 and were selected voluntarily using purposeful sampling. The Power Analysis and Sample Size software version 15 (PASS15) were used to estimate the sample size. The sample group consisted of 83 men and 32 women (115 total), and their ages were reported to be between 65 and 85 years. The study was conducted in a private clinic in Tehran. For eligibility, the participants had to be between 65 - 85 years of age, live independently, have at least a high school diploma degree, score 85 and above in the Addenbrooke test, and read and sign the informed consent form. The exclusion criteria were using any other cognitive enhancement method (like brain training software, neuro-feedback, and TDCS) and suffering from a psychiatric disorder, any physical illness inter-

fering with the participant's enrollment in the study, and alcohol and drug abuse. In order to collect the information required for the research, questionnaires and cognitive tasks were used. The psychological well-being questionnaire (5), executive function tasks, and the adult socio-emotional loneliness questionnaire (16) were used. The participants filled out the questionnaires and performed the tests before the examiners.

2.1. The Psychological Well-Being Scale

This questionnaire measures six factors of Ryff's psychological well-being model with 84 questions. Six factors include positive relationships, environmental mastery, self-acceptance, autonomy, personal growth, and purpose in life. Ryff (1989) reported Cronbach's alpha value of self-acceptance as 0.93, positive relationship with others as 0.91, autonomy as 0.86, environmental mastery as 0.90, purpose in life as 0.90, and personal growth as 0.87. Lindfors et al. reported the internal stability coefficient to range between 0.65 and 0.70 for different factors of the questionnaire (17). In a study in Iran (2008), Cronbach's Alpha value of the questionnaire was reported above 0.70 for all the factors, and the results of factor analysis with six factors were favorable (18).

2.2. The Social and Emotional Loneliness Scale for Adults (SELSA)

The scale contains 15 items answered on a 7-point Likert scale. The scale also includes three loneliness factors: social, family, and romantic. The Cronbach's alpha (α) of the scale was calculated, and it was satisfactory. The internal consistency results are as follows for each factor: Social ($\alpha = 0.90$), family ($\alpha = 0.89$), and romantic ($\alpha = 0.87$) (19). In Iran, the reliability and validity of the scale were investigated in a study. The results confirmed the existence of three factors (20).

2.3. The Reaction Time Test (RT)

Simple reaction time (SRT) tests, where subjects simply respond as fast as possible to the occurrence of a stimulus, are among the most basic measures of processing speed. Francis Galton first studied RTs in the late 19th century. Test-retest reliability for the RT was 0.53 using mean scores and 0.65 using median scores (21).

2.4. Mathematical Processing Task

This task asks participants to answer simple math problems. This task is based on the math processing task in the UTC test battery. A correlation of 0.41 has been reported by computing the answers; participants answer whether the answer is higher or lower than 5, allowing for “yes-no” responses. They were patterned after the math processing test described by Perez et al. (1987) (22).

2.5. Tower of London

The Tower of London test was first developed by Shallice in 1982 to assess 14 patients with frontal lobe injury. This test assesses the ability to implement planning or strategic planning and problem-solving. The reliability of this test was acceptable and was reported at 0.79 (23).

2.6. Trail Making Task (TMT)

This test mainly measures cognitive flexibility and task alternation. In one study, the reliability of the test-retest of the forms A and B was investigated, and the correlation between the two forms was between 0.76 and 0.89 for the form A and 0.86 and 0.94 for the form B, which indicates the high reliability of the tool (24). This study used the paper-pencil model of this test and the sheets A, B, and A-B.

2.7. N-Back Test

This test measures cognitive performance related to executive functions and was first introduced in 1958 by Wayne Kirchner. Since this task involves storing and manipulating cognitive information, it is well-known for measuring working memory performance. Validity coefficients in the range between 0.55 and 0.88 showed the high validity of the test. The validity of the test is also very acceptable as an indicator of working memory performance (25).

3. Results

In the first stage of the analysis, the zero-order correlation matrix of the explicit variables is reported.

As shown in Table 1, most of the observed variables were significantly correlated with each other. It was observed that the components of perceived loneliness had an inverse relationship with well-being and executive functions. Executive functions had a positive relationship with well-being components. Then, the relationships of the variables were tested in the form of a structural model.

Before performing the structural model analysis, the assumptions of this model, such as the normal distribution of data, and the absence of inflation and alignment in the explicit variables, were examined.

As shown in Table 2, the value of the chi-square index per degree of freedom was 2.07, the value of the normed fit index (NFI) was 0.88, the comparative fit index (CFI) was 0.95, the incremental fit index (IFI) was 0.95, and the adjusted goodness-of-fit index (AGFI) was 0.88, the goodness of fit index (GFI) was 0.91, and the root mean square error of approximation (RMSEA) was 0.047. These results indicated that the structural model of the research had a firm fit, and it was acceptable. Accordingly, factor loads and path coefficients obtained from the model were reported in the form of figures and tables in the following.

Table 3 reports the factor loads and their significance along with the multivariate correlation coefficient of each of the apparent variables of the model. As can be seen, all the reported coefficients were significant and well supported their latent attribute.

In the following, direct and indirect coefficients between the variables of feeling lonely, executive functions, and well-being of the elderly were reported.

As shown in Table 4 (also in Figure 1), the relationship between perceived loneliness and executive functions (-0.82) was inverse and significant. Also, the relationship between executive functions and well-being (1.84) was positive and significant, and the relationship between loneliness and well-being was negative and significant (-0.69). The results showed that the indirect effect of loneliness on well-being (0.566) was positive and significant. In other words, an executive function was able to reduce the impact of perceived loneliness on well-being. Thus, it can be stated that executive functions play a significant mediating role in the relationship between loneliness and the well-being of the elderly.

4. Discussion

This research aimed to investigate the role of executive functions concerning the perceived loneliness and psychological well-being of the elderly. The results showed that executive functions could significantly reduce the negative effect of loneliness on the well-being of the elderly. Although the underlying mechanisms of such a relationship are unclear, existing research suggests three potential explanations for the relationship between loneliness and executive functions and their implications for well-being and its components. Loneliness can lead to behaviors such as

Table 1. The Zero-Order Correlation Matrix of Explicit Variables

Variables	1	2	3	4	5	6	7
1- Romantic loneliness	1						
2- Family loneliness	0.377**	1					
3- Social loneliness	0.023	0.563**	1				
4- Working memory	-0.282**	-0.224*	-0.15	1			
5- Cognitive flexibility	-0.288**	-0.278**	-0.191*	0.310**	1		
6- Quantitative reasoning	-0.133	-0.240**	-0.178	0.097	0.133	1	
7- Planning	-0.279**	-0.157	-0.162	0.324**	0.220*	0.143	1
8- Reaction time	-0.369**	-0.219*	-0.085	0.161	0.315**	-0.085	0.085
9- Self-acceptance	-0.312**	-0.233*	-0.103	0.439**	0.415**	0.400**	.315**
10- Positive relations	-0.293**	-0.299**	-0.259**	0.311**	0.340**	0.392**	0.126
11- Autonomy	-0.373**	-0.496**	-0.304**	0.268**	0.447**	0.218*	0.281**
12- Environmental mastery	-0.434**	-0.397**	-0.195*	0.284**	0.280**	0.218*	0.364**
13- Purpose in life	-0.425**	-0.225*	-0.126	0.437**	0.467**	0.029	0.226*
14 Personal growths	-0.267**	-0.237*	-0.235*	0.230*	0.399**	0.379**	0.419**
Variables	8	9	10	11	12	13	14
8- Reaction time	1						
9- Self-acceptance	0.315**	1					
10- Positive relations	0.320**	0.405**	1				
11- Autonomy	0.249**	0.188*	0.117	1			
12- Environmental mastery	0.301**	0.205*	0.174	0.308**	1		
13- Purpose in life	0.436**	0.282**	0.14	0.319**	0.178	1	
14 Personal growths	0.241**	0.298**	0.348**	0.328**	0.188*	0.161	1

Table 2. Structural Model Fit Indices

χ^2	df	χ^2/df	NFI	CFI	IFI	RFI	GFI	AGFI	RMSEA
153.8	74	2.078378	0.88	0.95	0.95	0.89	0.91	0.88	0.047

inactivity, decreased participation in situations that lead to the use and exercise of cognitive abilities, increased alcohol consumption, smoking, and sleep disorders, all of which are considered risk factors for cognitive decline (26); there are also biological pathways through which loneliness can affect executive functions (2). For example, it has been reported that loneliness can increase cortisol levels, which, in the long term, can have adverse effects on neurons involved in memory. Loneliness can also deprive individuals of the benefits of social relationships such as self-efficacy, social support, meaning, and purpose in life, which increases the risk of cognitive impairment (27).

In addition, these results showed that with the reduction of executive functions, the psychological well-being of the elderly decreased, which can be interpreted according to the variables existing in psychological well-

being and the role of executive functions in them. Self-sufficiency and self-satisfaction play an essential role in the sub-component of self-acceptance, which can be explained by the role of executive functions in performing daily actions and the role they play in maintaining the independence of the elderly. Regarding the components of positive communication and autonomy, the concept of social competence and its relationship with executive functions can be used. Social competence is the ability of an individual to achieve social goals and perform communication functions required in a particular situation while taking advantage of the linguistic, cultural, and social needs of that situation. Research has shown that executive functions play an essential role in people's social competence. Items such as programming, working memory, cognitive flexibility, inhibition, and processing speed are critical to establishing

Table 3. The Factor Relationships and Loads of Explicit Variables Relative to Their Latent Trait

Variables	λ Coefficient	Std Error	T Value	Multivariate Correlation Coefficient
Romantic loneliness	1.82	0.15	12.54	0.75
Family loneliness	1.51	0.17	8.92	0.58
Social loneliness	1.26	0.2	6.46	0.23
Working memory	1.23	—	—	0.19
Cognitive flexibility	1.40	0.15	9.42	0.22
Quantitative reasoning	1.20	0.14	8.91	0.18
Planing	0.78	0.11	6.97	0.12
Reaction time	1.40	0.14	9.77	0.19
Self-acceptance	1.97	—	—	0.28
Positive relations	1.57	0.18	8.73	0.19
Autonomy	1.46	0.14	10.19	0.23
Environmental mastery	1.72	0.16	10.63	0.24
Purpose in life	1.87	0.18	10.35	0.25
Personal growth	1.84	0.2	9.25	0.27

Table 4. Indirect and Direct Effects on the Structural Model

Independent Variable	Dependent Variable	Direct Effect	Std Dev	T Value	Multivariate Correlation Coefficient	Indirect Effect	Total Effect
Perceived loneliness	Executive function	-0.82	0.098	-8.41**	0.28	—	-0.82
Executive function	Psychological-wellbeing	1.84	0.25	7.34**	0.504	—	1.84
Perceived loneliness	Psychological-wellbeing	-0.69	0.25	-2.76**	0.504	0.566	-0.124

and maintaining relationships (28).

These results should be considered by observing the limitations of the study. (1) We had more males than females in our sample. These findings need to be confirmed in future research. (2) This research was conducted on elderly aged 65–85 years old. Future studies can include a broader age range. (3) We only assessed working memory in this research. Other memory processes should be included in future studies to gain a more detailed picture of the memory and loneliness relationship. (4) Our study was cross-sectional, meaning that the relationship between cognitive measures, well-being, and loneliness could not be proven causally for future studies. However, our participants were vital elderly without severe physical and mental issues. It is recommended to assess medical issues in participants more comprehensively in future studies.

4.1. Conclusions

It can be concluded that the reduction of executive functions can directly affect the quality of social interactions, and the quality of social interactions, in turn, can

affect the perceived loneliness in old age. On the issue of environmental dominance, research has shown that cognitive flexibility is one of the variables that can positively impact people's interactions in the environment and concerning new and unknown cases. Goal setting and achieving goals require planning and problem-solving skills that are essential parts of executive functions, and for cognitive development, it is necessary to define the formation of new behaviors and attitudes and learn new skills that are part of executive functions and play an essential role in providing them (29).

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Footnotes

Authors' Contribution: Amir Etemadi: Preparing and conceiving the study, recruiting participants, acquiring data, performing statistical analysis, interpreting data,

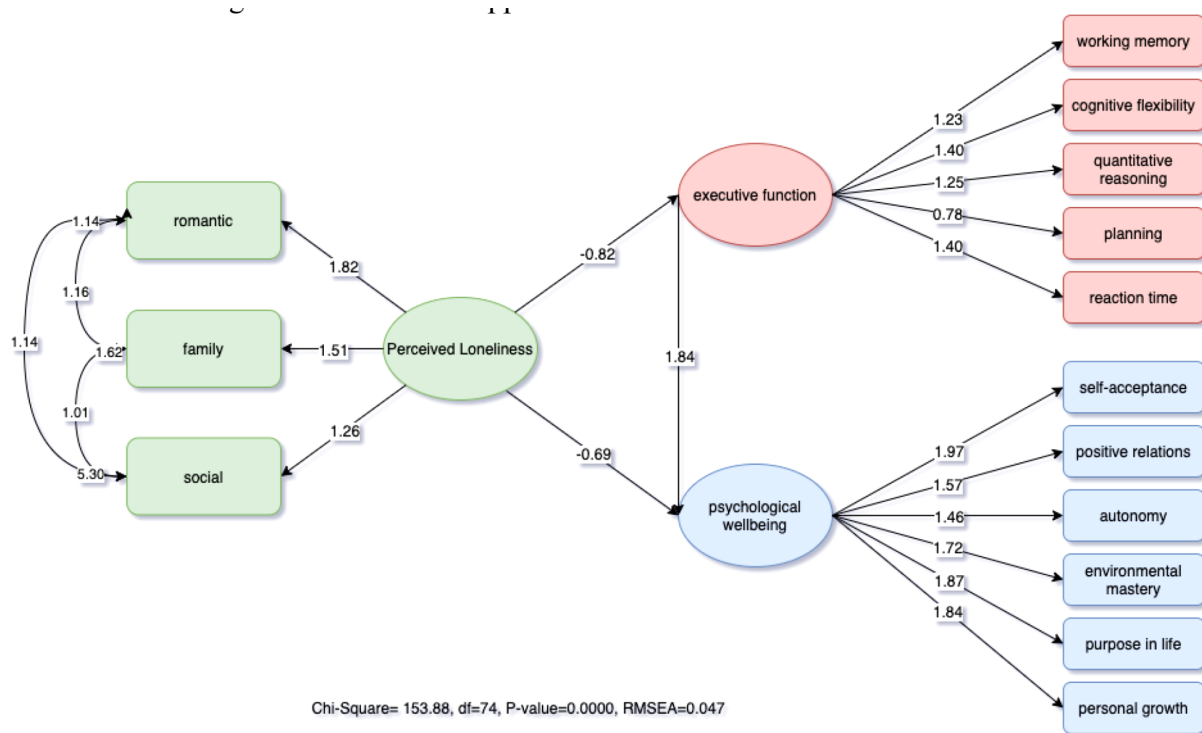


Figure 1. The diagram of path coefficients and relationships between variables in the structural equations of research.

and drafting the manuscript; Paria Etemadi: Supporting statistical analysis, interpreting data, and revising the manuscript; Ghasem Keshavarz: Conceiving the study, interpreting the data, and revising the manuscript.

Conflict of Interests: The authors report no conflicts of interest in this work.

Data Reproducibility: The data presented in this study are openly available in Mendeley at 10.17632/krcb3byk68.1.

Ethical Approval: IR.KHU.REC.1398.043 (link: ethics.research.ac.ir/EthicsProposalView.php?id=105833).

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References

- Saydshohadai M, Heshmat S, Seidfatem N, Haghani H, Mehrdad N. [The spiritual health of seniors living in sanitarium and home residents]. *Iran J Nurs*. 2013;**26**(81):11–20. Persian.
- Boss L, Kang DH, Branson S. Loneliness and cognitive function in the older adult: a systematic review. *Int Psychogeriatr*. 2015;**27**(4):541–53. doi: [10.1017/S1041610214002749](https://doi.org/10.1017/S1041610214002749). [PubMed: 25554219].
- Demakakos P, Nunn S, Nazroo J. Loneliness, relative deprivation and life satisfaction. In: Banks J, Breeze E, Lessof C, Nazroo J, editors. *Retirement, Health and Relationships of the Older Population in England: The 2004 English Longitudinal Study of Ageing (wave 2)*. London, United Kingdom: Institute for Fiscal Studies; 2006.
- Iwasa H, Kawaai C, Gondo Y, Inagaki H, Suzuki T. Subjective well-being as a predictor of all-cause mortality among middle-aged and elderly people living in an urban Japanese community: A seven-year prospective cohort study. *Geriatr Gerontol Int*. 2006;**6**(4):216–22. doi: [10.1111/j.1447-0594.2006.00351.x](https://doi.org/10.1111/j.1447-0594.2006.00351.x).
- Ryff CD, Keyes CL. The structure of psychological well-being revisited. *J Pers Soc Psychol*. 1995;**69**(4):719–27. doi: [10.1037//0022-3514.69.4.719](https://doi.org/10.1037//0022-3514.69.4.719). [PubMed: 7473027].
- Dodge R, Daly AP, Huyton J, Sanders LD. The challenge of defining well-being. *Int J Wellbeing*. 2012;**2**(3):222–35. doi: [10.5502/ijw.v2.i3.4](https://doi.org/10.5502/ijw.v2.i3.4).
- Mellor D, Stokes M, Firth L, Hayashi Y, Cummins R. Need for belonging, relationship satisfaction, loneliness, and life satisfaction. *Pers Individ Differ*. 2008;**45**(3):213–8. doi: [10.1016/j.paid.2008.03.020](https://doi.org/10.1016/j.paid.2008.03.020).
- Hawkey LC, Cacioppo JT. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Ann Behav Med*. 2010;**40**(2):218–27. doi: [10.1007/s12160-010-9210-8](https://doi.org/10.1007/s12160-010-9210-8). [PubMed: 20652462]. [PubMed Central: PMC3874845].
- Tilvis RS, Routasalo P, Karppinen H, Strandberg TE, Kautiainen H, Pitkala KH. Social isolation, social activity and loneliness as survival indicators in old age: a nationwide survey with a 7-year follow-up. *Eur Geriatr Med*. 2012;**3**(1):18–22. doi: [10.1016/j.eurger.2011.08.004](https://doi.org/10.1016/j.eurger.2011.08.004).
- Kong D, Davitt J, Dong X. Loneliness, Depressive Symptoms, and Cognitive Functioning Among U.S. Chinese Older Adults. *Gerontol Geriatr Med*. 2018;**4**:2333721418778200. doi: [10.1177/2333721418778201](https://doi.org/10.1177/2333721418778201). [PubMed: 30038951]. [PubMed Central: PMC6050813].
- Salthouse TA. Neuroanatomical substrates of age-related cognitive decline. *Psychol Bull*. 2011;**137**(5):753–84. doi: [10.1037/a0023262](https://doi.org/10.1037/a0023262). [PubMed: 21463028]. [PubMed Central: PMC3132227].

12. Alzheimer's Association. 2016 Alzheimer's disease facts and figures. *Alzheimers Dement*. 2016;**12**(4):459-509. doi: [10.1016/j.jalz.2016.03.001](https://doi.org/10.1016/j.jalz.2016.03.001). [PubMed: [27570871](https://pubmed.ncbi.nlm.nih.gov/27570871/)].
13. Henry JD, Cowan DG, Lee T, Sachdev PS. Recent trends in testing social cognition. *Curr Opin Psychiatry*. 2015;**28**(2):133-40. doi: [10.1097/YCO.0000000000000139](https://doi.org/10.1097/YCO.0000000000000139). [PubMed: [25630050](https://pubmed.ncbi.nlm.nih.gov/25630050/)].
14. Rizkalla MN. Cognitive training in the elderly: a randomized trial to evaluate the efficacy of a self-administered cognitive training program. *Aging Ment Health*. 2018;**22**(10):1384-94. doi: [10.1080/13607863.2015.1118679](https://doi.org/10.1080/13607863.2015.1118679). [PubMed: [26644269](https://pubmed.ncbi.nlm.nih.gov/26644269/)].
15. Adamski N, Adler M, Opwis K, Penner IK. A pilot study on the benefit of cognitive rehabilitation in Parkinson's disease. *Ther Adv Neurol Disord*. 2016;**9**(3):153-64. doi: [10.1177/17562856166628765](https://doi.org/10.1177/17562856166628765). [PubMed: [27134671](https://pubmed.ncbi.nlm.nih.gov/27134671/)]. [PubMed Central: [PMC4811010](https://pubmed.ncbi.nlm.nih.gov/PMC4811010/)].
16. DiTommaso E, Brannen C, Best LA. Measurement and Validity Characteristics of the Short Version of the Social and Emotional Loneliness Scale for Adults. *Educ Psychol Meas*. 2016;**64**(1):99-119. doi: [10.1177/0013164403258450](https://doi.org/10.1177/0013164403258450).
17. Lindfors P, Berntsson L, Lundberg U. Factor structure of Ryff's psychological well-being scales in Swedish female and male white-collar workers. *Pers Individ Differ*. 2006;**40**(6):1213-22. doi: [10.1016/j.paid.2005.10.016](https://doi.org/10.1016/j.paid.2005.10.016).
18. Bayani AA, Mohammad Koochekya A, Bayani A. [Reliability and validity of Ryff's psychological well-being scales]. *Iran J Psychiatry Clin Psychol*. 2008;**14**(2):146-51. Persian.
19. Guimarães Amorim LA, Nunes da Fonsêca P, Marcolino Alves Machado G, Cardoso Guimarães CL, Nascimento da Silva PG. [Social and Emotional Loneliness Scale for Adults: Psychometric evidence in northeastern Brazil]. *Cien Psicol*. 2019;283-95. Portuguese. doi: [10.22235/cp.v13i2.1885](https://doi.org/10.22235/cp.v13i2.1885).
20. Jowkar B. [Psychometric properties of the short form of the social and emotional loneliness scale for adults (SELSA-S)]. *Int J Behav Sci*. 2012;**5**(4):311-7. Persian.
21. Sternberg S. The discovery of processing stages: Extensions of Donders' method. *Acta Psychol (Amst)*. 1969;**30**:276-315. doi: [10.1016/0001-6918\(69\)90055-9](https://doi.org/10.1016/0001-6918(69)90055-9).
22. Perez WA, Masline P, Ramsey EG, Urban KE. *Unified tri-services cognitive performance assessment battery: Review and methodology*. San Diego, CA, USA; 1987. Report No.: 78-10.
23. Lezak MD, Howieson DB, Loring DW, Hannay HJ, Fischer JS. *Neuropsychological assessment*. 4th ed. Oxford, New York, USA: Oxford University Press; 2004.
24. Wagner S, Helmreich I, Dahmen N, Lieb K, Tadic A. Reliability of three alternate forms of the trail making tests a and B. *Arch Clin Neuropsychol*. 2011;**26**(4):314-21. doi: [10.1093/arclin/acr024](https://doi.org/10.1093/arclin/acr024). [PubMed: [21576092](https://pubmed.ncbi.nlm.nih.gov/21576092/)].
25. Kane MJ, Conway ARA, Miura TK, Colflesh GJH. Working memory, attention control, and the N-back task: a question of construct validity. *J Exp Psychol Learn Mem Cogn*. 2007;**33**(3):615-22. doi: [10.1037/0278-7393.33.3.615](https://doi.org/10.1037/0278-7393.33.3.615). [PubMed: [17470009](https://pubmed.ncbi.nlm.nih.gov/17470009/)].
26. Baumgart M, Snyder HM, Carrillo MC, Fazio S, Kim H, Johns H. Summary of the evidence on modifiable risk factors for cognitive decline and dementia: A population-based perspective. *Alzheimers Dement*. 2015;**11**(6):718-26. doi: [10.1016/j.jalz.2015.05.016](https://doi.org/10.1016/j.jalz.2015.05.016). [PubMed: [26045020](https://pubmed.ncbi.nlm.nih.gov/26045020/)].
27. Fratiglioni L, Paillard-Borg S, Winblad B. An active and socially integrated lifestyle in late life might protect against dementia. *Lancet Neurol*. 2004;**3**(6):343-53. doi: [10.1016/S1474-4422\(04\)00767-7](https://doi.org/10.1016/S1474-4422(04)00767-7). [PubMed: [15157849](https://pubmed.ncbi.nlm.nih.gov/15157849/)].
28. Wang M, Saudino KJ. Emotion Regulation and Stress. *J Adult Dev*. 2011;**18**(2):95-103. doi: [10.1007/s10804-010-9114-7](https://doi.org/10.1007/s10804-010-9114-7).
29. Blakemore SJ, Choudhury S. Development of the adolescent brain: implications for executive function and social cognition. *J Child Psychol Psychiatry*. 2006;**47**(3-4):296-312. doi: [10.1111/j.1469-7610.2006.01611.x](https://doi.org/10.1111/j.1469-7610.2006.01611.x). [PubMed: [16492261](https://pubmed.ncbi.nlm.nih.gov/16492261/)].