



Investigating the Performance of Selective Attention and Working Memory in Adolescents Recovered from Acute Covid-19 with Normal Adolescents

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Selective attention is a state of attention in which a person can choose the target stimulus from among various stimuli and track it. A body of research shows that covid-19 infection is associated with cognitive deficits. Therefore, the aim of the present study is to investigate the performance of selective attention and working memory in adolescents recovered from acute and normal covid-19. The current study was a causal-comparative which was conducted on 59 adolescents aged 15 to 20 years who recovered from acute and normal covid-19 in 1400 in Karaj city, Iran. Selective attention was evaluated through the complex Stroop word software test and active memory through the Wechsler memory test, and Goldberg mental health questionnaire and the Wechsler intelligence test for blind people. By comparing the average scores of the two groups, it can be seen that the selective attention of normal adolescents is higher compared to adolescents who have recovered from acute Covid-19. By comparing the average scores of the two groups, it can be seen that the working memory of normal adolescents is higher compared to adolescents who have recovered from acute Covid-19. Based on the findings of the present study, selective attention and active memory of the recovered adolescent have been affected by Covid-19 during this period. Based on this, it is suggested to conduct research with a wider statistical population to identify the types of cognitive weaknesses of people who have recovered from Covid-19, so that major cognitive disorders can be prevented in time.

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Introduction

Novel Corona virus (SARS-COV-2) has continued to spread across the world in recent months rapidly. Corona virus is actually a large family of viruses that cause respiratory infections from a common cold to more severe diseases such as MERS and SARS. In other words, Covid-19 is the newest member of this family. Currently, Covid-19 pandemic is one of the most important public health concerns in Iran and all over the world

After the increase in the number of people infected with this virus worldwide, on January 30, 2020, the World Health Organization announced the outbreak of this disease as a public health emergency with concern by publishing a statement (World Health Organization, WHO, 2020). This virus affects people's immune system and causes symptoms of high fever, severe cough, loss of smell or taste, shortness of breath, and acute respiratory symptoms (Sharietnia, 2019). The world health system is severely affected by the Covid-19 pandemic (Lipsich et al., 2020). The epidemic and limitations of this disease cause adverse psychological effects in people (Hetong Zhu et al., 2020). Among the population groups, teenagers are among the groups at risk of this epidemic. People who have recovered from acute Covid-19, especially those hospitalized, have significantly shown major neurological and mental illnesses (Zhao et al., 2022). The symptoms of this disorder are similar to SARS (Yap, 2018). According to the conducted research, in SARS patients, complaints of cognitive disorders such as poor concentration, memory loss, etc. have been seen (Sheng et al., 2005).

Cognitive functions include attention, orientation, memory, problem solving, etc., and any disturbance in it reveals problems in higher brain processes (Jama, 2020). Among these cognitive functions is attention. Attention is a set of processes that has the task of maintaining purposeful behavior against distractions (Parasuraman, 2000). Attention can be classified into various types, each of which has a different function; including selective attention, sustained attention, divided attention, etc. (Skermer, 2005; Cohen, 2014). Selective attention is a state of

attention in which a person can choose the target stimulus from among various stimuli and track it (Scramer, 2005). Also, selective attention includes subject processing where a person selectively processes the desired event and ignores other events (Lezak, 1995). Another cognitive function of people; It is memory (Sternberg, 2006). Memory refers to the place of storage, collection and retrieval of information related to the past (Bjorklund and Schinder, 2003). One of the types of memory is active memory. Working memory provides the power of temporary storage and manipulation of information for difficult cognitive activities (Rapin, 2008). This memory is responsible for the active maintenance of current information and its capacity is limited (Bahri, 2014). In addition, the temporary storage of information stored in this memory is necessary for all other cognitive functions, and its dysfunction causes disruption in people's fasting performance (Wanmaker, 2015).

The research conducted in the field of the relationship between Covid-19 and cognitive functions shows different results. A body of research shows that covid-19 infection is associated with cognitive deficits that persist until the recovery phase (Humptshire et al., 2021). Previous studies in Covid-19 patients show that people show attention disorders several weeks after recovery from the disease (Almeria et al., 2020; Zhou et al., 2020; McLoughlin et al., 2020). Also, findings have shown that increased anxiety reduces the capacity of working memory through their distraction (McVeigh and Kane, 2010; Purio et al., 2013; Smallwood and Schooler, 2015). Therefore, the findings of Baseler and his colleagues (2022) show that Covid-19 has a negative effect on working memory (Basler and Hekaran, 2022). Kira et al. On the other hand, another group has shown that approximately one fifth of Covid-19 patients express different degrees of memory complaints during one year. However, they did not find any relationship between the severity of Covid-19 and memory complaints (Ahad et al., 2022).

Although the epidemiological and clinical features of COVID-19 patients have been well studied and

researchers have published a large number of related studies, not enough attention has been paid to the effect of this virus on cognitive functions such as selective attention and working memory (Geo et al., 2020). Therefore, the aim of the present study is to investigate the performance of selective attention and working memory in adolescents recovered from acute and normal covid-19.

Methodology

The current research was a causal-comparative which was conducted on 59 adolescents aged 15 to 20 who recovered from acute and normal covid-19 in 1400 in Karaj, Iran. In those people, they were divided into two groups, 29 teenagers recovered from acute Covid-19 and 30 normal teenagers. Individuals had to answer the software and paper-based tests, the total response time for each subject was 1 hour, and the person rested for 10 minutes between each test.

Instruments

In the present study, selective attention was evaluated through the complex Stroop word software test and working memory through the Wechsler memory test.

Stroop

The Stroop (1935) paradigm, of which there are many variants, has the potential to function as an EVI. The task usually consists of at least three trials (MacLeod & MacDonald, 2000). In the first trial, the participant is asked to read a series of color words, printed in black ink, as quickly as possible. In the second trial, the participant is asked to look at a series of color squares, and name the colors as quickly as possible. The third trial is the test of interference and the evoker of the classic Stroop effect: the participant is asked to look at a series of color words, printed in incongruent ink colors, and name the color of the ink instead of reading the word, as quickly as possible. For example, if the word "red" is printed in green ink, the examinee is asked to say "green" instead of "red." Because reading words is more automatized than naming ink colors, inhibiting the overlearned

response requires additional cognitive resources, which results in increased completion time relative to the word reading and color naming trials (MacLeod & MacDonald, 2000).

The Stroop paradigm has been shown to be sensitive to neuropsychiatric conditions with executive dysfunction as a common feature, such as traumatic brain injury (TBI; Larson, Kaufman, Schmalfuss, & Perlstein, 2007; Schroeter et al., 2007) and attention-deficit-hyperactivity disorder (ADHD; Lansbergen, Kenemans, & Van Engeland, 2007). However, there is limited research examining the utility of the Stroop paradigm as a measure of noncredible performance. Arentsen and colleagues (2013) introduced validity cutoffs for the word reading (66 s), color naming (93 s), and interference (191 s) trials in the Comalli Stroop Test (Comalli, Wapner, & Werner, 1962). All of these cutoffs achieved specificity .90 in a mixed clinical population, with .29 – .53 sensitivity⁴⁶.

WISC

The adult Wechsler IQ test was proposed by David Wechsler in 1995 to measure the cognitive performance of people aged 16 and over. This test consists of 77 subtests, 6 of which are verbal scales and 5 are practical scales. Scales of verbal intelligence include: general information, reading numbers, vocabulary, calculations, comprehension, and similarities, and scales of practical intelligence include completing pictures, arranging pictures, designing with cubes, connecting parts, and symbols of numbers. Retest validity in the interval of one to 1 week for the overall scale (0.97), verbal scale (0.97) and non-verbal scale (0.93), the reliability of the test by dividing it into two halves for the overall scale (0.97), Verbal scale (0.97) and non-verbal scale (0.93) and standard error of measurement for general scale (2.53), verbal scale (2.74) and non-verbal scale (4.14) have been reported (Harnath, 1997).

Procedure

First, the researchers were given preliminary explanations about filling the questionnaire and

also the steps of software tests to the participants. After the end of the tests, the data was analyzed. Data analysis has been done at the descriptive and inferential level. At the descriptive level, to measure the variables of the research, measures of tendency to the center (mean) and measures of dispersion from the center (standard deviation) have been used. Independent t-test and multivariate analysis of variance (MANOVA) were used in the inferential part. SPSS_26 statistical software was used for data analysis.

Findings

The data of this research was collected during 4 months from March 2021 to June 2021. In the present study, our statistical population was recovered teenagers living in Karaj city. Among the people present in the research, 29 people are teenagers who have recovered from acute Covid-19 and 30 people are normal teenagers.

In the descriptive statistics section, the mean and standard deviation of selective attention and active memory scores were analyzed separately for individuals in the groups of adolescents recovered from acute and normal covid 19. The covariance

matrix (box) test showed that the significance level of the box test was equal to 0.76. is 0. According to Table 1, since this value is greater than the significance level (0.05) required to reject the null hypothesis, the null hypothesis based on the homogeneity of the covariance matrix is confirmed. Levine's test was used to check the homogeneity of variances. The results of this test are not significant in any of the variables. Therefore, the null hypothesis for the homogeneity of the variance of the variables is confirmed. Also, multivariate analysis of covariance was used to compare the selective attention of recovered adolescents with acute and normal covid 19. The results showed that the significance level of all four relevant multivariate statistics, namely Pillai's effect, Wilks's lambda, Hotelling's effect and the largest zinc root, is less than 0.01 ($p < 0.01$). In this way, it is clear that there is a significant difference between the selective attention of the two groups of teenagers recovered from acute and normal covid 19.

In order to investigate the difference between the two groups in each of the components of selective attention, the between-subjects test was used, the results of which are presented below.

Table 1: Test of between-subjects effects to compare the components of selective attention of recovered adolescents with acute and normal Covid 19

Source	Dependent variable	SS	df	MS	F	sig	Effect size
Group	Time response 1	17177.745	1	17177.745	10.030	0.002	0.150
	Error 1	697.842	1	697.842	18.227	0.001	0.242
	Without response 1	6950.990	1	6950.990	5.709	0.020	0.091
	Correct 1	18398.487	1	18398.487	9.074	0.004	0.137
	Time reaction 1	365552.199	1	365552.199	12.019	0.001	0.174
	Time response 2	14173.831	1	14173.831	6.754	0.012	0.106
	Error 2	9086.055	1	9086.055	6.440	0.014	0.102
	Without response 2	6903.967	1	6903.967	4.668	0.035	0.076
	Correct 2	24564.369	1	24564.369	8.148	0.006	0.125
	Time reaction 2	428865.320	1	428865.320	8.708	0.005	0.133
Error	Time response 1	97616.662	57	1712.573			
	Error 1	2182.328	57	38.286			
	Without response 1	69401.518	57	1217.570			
	Correct 1	115569.174	57	2027.529			
	Time reaction 1	1733682.208	57	30415.477			
	Time response 2	119625.390	57	2098.691			

	Error 2	80423.674	57	1410.942
	Without response 2	84302.948	57	1478.999
	Correct 2	171834.139	57	3014.634
	Time reaction 2	2807359.425	57	49251.920
Total	Time response 1	114794.407	58	
	Error 1	2880.169	58	
	Without response 1	76352.508	58	
	Correct 1	133967.661	58	
	Time reaction 1	2099234.407	58	
	Time response 2	133799.220	58	
	Error 2	89509.729	58	
	Without response 2	91206.915	58	
	Correct 2	196398.508	58	
	Time reaction 2	114794.407	58	

In Table 1, the results of the between-subjects effects test are shown for comparing the selective attention of recovered adolescents with acute and normal Covid-19. According to the results presented in Table 1, the F value obtained for all components is significant at the alpha level of 0.05 ($p < 0.05$). Therefore, it is concluded that there is a difference between the selective attention of the recovered adolescent of acute and normal Covid-19. By comparing the average scores of the two groups, it can be seen that the selective attention of normal adolescents is higher compared to adolescents who have recovered from acute Covid-19. Levene’s test was used to check the homogeneity of variances. The results of this test

are not significant. Therefore, the null hypothesis for the homogeneity of the variance of the variables is confirmed.

Multivariate analysis of covariance has been used to compare the selective attention of adolescents recovered from acute and normal Covid-19. As can be seen in Table 2, the significance level of all four relevant multivariate statistics, namely Pillai's effect, Wilks's lambda, Hotelling's effect and the largest zinc root, is less than 0.01 ($p < 0.01$). In this way, it is clear that there is a significant difference between the selective attention of the two groups of teenagers recovered from acute and normal covid 19.

Table 2. The results of multivariate analysis of covariance for the comparison of the selective attention of recovered adolescents with acute and normal Covid 19

Effect	Tests	Amounts	F	Effect degree of freedom	Error degree of freedom	sig	Effect size
Group	Pilla’s effect	0.585	6.774	10	48	0.001	0.585
	Wliks’ lambda	0.415	6.774	10	48	0.001	0.585
	Hottelng’s trace	1.411	6.774	10	48	0.001	0.585
	Roy’s largrst root	1.411	6.774	10	48	0.001	0.585

Independent t-test was used in order to compare the working memory performance of recovered adolescents with acute and normal Covid-19. The results of the independent t test show that the value of the obtained t statistic is equal to 14.618

and it is significant at the alpha level of 0.01 ($P < 0.01$). Therefore, it can be concluded that there is a difference between the active memory of the recovered adolescent of acute and normal Covid-19. By comparing the average scores of the two

groups, it can be seen that the working memory of normal adolescents is higher compared to

adolescents who have recovered from acute Covid-19.

Table 3. Results of independent t-test to compare the working memory of recovered adolescents with acute and normal covid-19

Variable	t	df	sig	Mean difference
Active memory	0.01	57	0.01	15.629

Conclusion

In recent years, one of the main concerns of people around the world has been to deal with the Covid-19 pandemic, and many people in the world are involved in its effects and consequences. Covid-19, which is a respiratory disease with symptoms similar to a cold, has the capacity to become a severe respiratory disease and even death of humans (Kasavandi, 2021). This pandemic has been able to create many effects and sufferings and involve every member of the family, from babies to the elderly. Also, in addition to the physical problems it has caused for people, it also threatens their mental health (Nagarestani et al., 2021). Since this virus has been more widespread than the previous common viruses in humans, hence its power of transmission is several times (Franush et al., 2019).

Also, since this virus may involve different aspects of human existence, it is important to pay attention to the cognitive functions of those who have recovered from this virus. Now, if the cognitive functions of these people, including their attention and memory, are examined and their defects are identified, these people will be helped to live better and their performance will improve in different dimensions. According to the issues raised, it can be pointed out that it seems that the cognitive functions of people who have recovered from acute covid-19 are affected compared to normal people. Therefore, the aim of the present study is to investigate the performance of selective attention and working memory in adolescents recovered from acute and normal covid-19. The results of the present study confirm the hypothesis that the performance of selective attention and working memory in normal adolescents is higher than in adolescents who have recovered from acute covid-19. There is no similar study that

examines and compares these results. However, there are studies that have each separately investigated the improved memory and attention performance of acute covid-19 and have obtained similar results. Therefore, the findings of the current research are consistent with these studies (Yap, 2018; Almeria et al., 2020; Lazarus et al., 2019).

Previous studies have shown that people with Covid-19 have a relatively high number of cognitive disorders, such as defects in memory function, mental classification, and information processing speed (Jacqueline et al., 2021). According to the research of Nikolen and his colleagues (2021), it can be said; Covid-19 patients have been weak in several tests in the functions of selective attention, active memory, divided attention and innate vigilance (Nikolin et al., 2021). Another group of studies has shown that the active memory of people with Covid-19 is caused by the experience of anxiety. It has been affected by infection in the first weeks of the epidemic (Fallman et al., 2020). Also, Germano et al. (2021) by examining the cognitive function of the patients of Covid-19 who have experienced a severe illness, concluded that 80% of them had defects in memory, executive function and language (Germano, 2021).

As a result of our study, it shows that adolescents who have recovered from acute Covid-19, after experiencing this virus, there were defects in their cognitive functions, including selective attention and working memory. Therefore, in the present study, it can be concluded that the performance of selective attention and active memory of adolescents recovered from Covid-19 has decreased. The results of our study can help to understand the long-term effect of the covid-19 virus on cognition and its effect on people's

behavior. As a result, by controlling these factors and carrying out the necessary interventions, it is possible to find benefits for people suffering from covid-19 and it is one of its harmful consequences. Based on the findings of the present study, the selective attention and working memory of the recovered adolescent has been affected by Covid-19 during this period. Based on this, it is suggested to conduct research with a wider statistical population to identify the types of cognitive weaknesses of people who have recovered from Covid-19, so that major cognitive disorders can be prevented in time. Also, extensive longitudinal studies help to identify these deficiencies. One of the limitations of this study was that the research was carried out in a group of people who did not want to cooperate. Nevertheless, it was tried to obtain reliable results from the implementation of this research.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Informed Consent

Written informed consent were obtained from eligible patients in their native language (Persian).

References

Ahmed, M., Roy, S., Iktidar, M. A., Chowdhury, S., Akhter, S., Islam, A. K., & Hawlader, M. D. H. (2022). Post-COVID-19 Memory Complaints: Prevalence and Associated Factors. *Neurología*. [Link]

Almeria, M., Cejudo, J. C., Sotoca, J., Deus, J., & Krupinski, J. (2020). Cognitive profile following COVID-19 infection: Clinical predictors leading to neuropsychological impairment. *Brain, behavior, & immunity-health*, 9, 100163. [Link]

BAHRI, M., AHMADI, E., & BAHRI, M. (2015). Working memory function in state and trait anxiety: Attentional control theory. (Persian)

Baseler, H. A., Aksoy, M., Salawu, A., Green, A., & Asghar, A. U. (2022). The negative impact of COVID-19 on working memory revealed using a rapid online quiz. *medRxiv*. [Link]

Farnoosh, G. (2020). Alis hiri G, Hosseini Zijoud SR, Dorostkar R, Jalali Farahani A. Understanding the 2019-novel Coronavirus (2019-nCoV) and Coronavirus Disease (COVID-19) based on available evidence-a narrative review. *Journal of Military Medicine*, 22(1), 1-11. (Doi: 10.30491/JMM.22.1.1)

Fellman, D., Ritakallio, L., Waris, O., Jylkkä, J., & Laine, M. (2020). Beginning of the pandemic: COVID-19-elicited anxiety as a predictor of working memory performance. *Frontiers in psychology*, 11, 576466. (<https://doi.org/10.3389/fpsyg.2020.576466>)

Hampshire, A., Trender, W., Chamberlain, S. R., Jolly, A. E., Grant, J. E., Patrick, F., ... & Mehta, M. A. (2021). Cognitive deficits in people who have recovered from COVID-19. *EClinicalMedicine*, 39, 101044. (<https://doi.org/10.1016/j.eclinm.2021.101044>)

Jabri (2021). Psychological considerations in children and adolescents during the Covid-19 crisis. *Komesh* 23(3), 317-319. (Persian)

Jama, J. W., Launer, L. J., Wittelman, J. C. M., Den Breeijen, J. H., Breteler, M. M. B., Grobbee, D. E., & Hofman, A. (1996). Dietary antioxidants and cognitive function in a population-based sample of older persons: the Rotterdam Study. *American journal of epidemiology*, 144(3), 275-280. (<https://doi.org/10.1093/oxfordjournals.aje.a008922>)

Kasavandi, Amirani, & Pirzadeh Nouri. A review of the correlation between anxiety and the spread of covid 19. (1400) *New Journal of Cellular and Molecular Biotechnology* 11(43), 0-0. (Persian)

Kira, I. A., Alpay, E. H., Turkeli, A., Shuwiekh, H. A., Ashby, J. S., & Alhuwailah, A. (2021). The effects of COVID-19 traumatic stress on

- executive functions: The case of Syrian refugees in Turkey. *Journal of Loss and Trauma*, 26(7), 666-687. (<https://doi.org/10.1080/15325024.2020.1869444>)
- McLoughlin, B. C., Miles, A., Webb, T. E., Knopp, P., Eyres, C., Fabbri, A., & Davis, D. (2020). Functional and cognitive outcomes after COVID-19 delirium. *European Geriatric Medicine*, 11(5), 857-862. (<https://doi.org/10.1007/s41999-020-00353-8>)
- Melchiorre, M. G., Chiatti, C., Lamura, G., Torres-Gonzales, F., Stankunas, M., Lindert, J., & Soares, J. F. (2013). Social support, socio-economic status, health and abuse among older people in seven European countries. *PloS one*, 8(1), e54856. (<https://doi.org/10.1371/journal.pone.0054856>)
- Nagarestani, Rashidi, Mohammadzadeh, Burhaninejad, & Vahidreza. (2021). Mental health of the elderly in the covid-19 pandemic: the role of exposure to the media. *Almand Scientific Research Journal* 16(1), 74-85.
- Nikolin, S., Tan, Y. Y., Schwaab, A., Moffa, A., Loo, C. K., & Martin, D. (2021). An investigation of working memory deficits in depression using the n-back task: A systematic review and meta-analysis. *Journal of Affective Disorders*, 284, 1-8. (<https://doi.org/10.1016/j.jad.2021.01.08>)
- Novel Coronavirus (2019-nCoV) and Coronavirus Disease (COVID-19) Based on Available Evidence - A Narrative Review. *J Mil Med*. 2020; 22(1): 1-11. (Persian)
- Parasuraman, R. (2000). The attentive brain: issues and prospects. *The attentive brain*, 3-16. (Persian)
- Schermer, C. R., (2005), "Language Learning Disorder", *Journal Pediatric*, 8:2.Sci.22(4):656-9. (doi: [10.30471/EDU.2019.1526](https://doi.org/10.30471/EDU.2019.1526))
- Sheng, B., Cheng, S. K. W., Lau, K. K., Li, H. L., & Chan, E. L. Y. (2005). The effects of disease severity, use of corticosteroids and social factors on neuropsychiatric complaints in severe acute respiratory syndrome (SARS) patients at acute and convalescent phases. *European psychiatry*, 20(3), 236-242. (<https://doi.org/10.1016/j.eurpsy.2004.06.023>)
- WHO, G. (2020). Statement on the second meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV). *World Health Organization*.
- Zhao, S., Shibata, K., Hellyer, P. J., Trender, W., Manohar, S., Hampshire, A., & Husain, M. (2022). Rapid vigilance and episodic memory decrements in COVID-19 survivors. *Brain Communications*, 4(1), fcab295. (<https://doi.org/10.1093/braincomms/fcab295>)
- Zhou, H., Lu, S., Chen, J., Wei, N., Wang, D., Lyu, H., & Hu, S. (2020). The landscape of cognitive function in recovered COVID-19 patients. *Journal of psychiatric research*, 129, 98-102. (<https://doi.org/10.1016/j.jpsychires.2020.06.022>)