
THE IMPACT OF COVID-19 PANDEMIC ON THE COGNITIVE FUNCTIONS OF THE INTERNATIONAL STUDENTS ENROLLED IN GEORGIAN UNIVERSITIES

Rekha Baskar¹

Student at Healthcare Sciences

East European University

Khatuna Parkosadze²

Associate Professor, Doctor of Biology

Senior Researcher, Doctor of Biology

East European University, Free University of Tbilisi

Abstract

The impact of COVID-19 on lifestyle, mental and physical health in students is well investigated but little is known regarding such impact on cognitive functions of international students. In the frame of presented study, the cognitive functions of international students enrolled in Georgian universities were investigated. Two groups of students were tested – students who stayed in Georgia during the pandemic period, and students who stayed in their country of origin with their families (mainly in India).

The data was collected from August 2021 to April 2022. The stress level of participants was evaluated via the Perceived Stress Scale (PSS) and cognitive functions were evaluated using Digit Span Tasks, Visual Search Task, and Wisconsin Card Sorting Test (WCST). The results showed that the perceived stress level for both groups' students was moderate and no significant difference between stress levels was measured. Results of cognitive tests showed that short-term and working memories are affected similarly in the two groups of students. However, performances of the visual search task and WCST showed that second-group students have a decline in attention and executive functions. These results indicate that the pandemic situation had affected international students in terms of stress similarly but deteriorated general cognitive functions in students who stayed with their families.

Keywords: *cognitive functions, executive functions, attention, memory, stress*

¹ rexbhas@gmail.com

² khatuna.parkosadze@eeu.edu.ge

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Introduction

The COVID-19 pandemic that started in Wuhan, China in December 2019 has turned out to be one of the most global and deadliest pandemic in world history (Feehan & Apostolopoulos, 2021). The pandemic situation generated serious physical and mental health problems at all levels of society. The consequences of the disease were very severe and the transmission of the disease was very quick, so in order to bring the situation under control World Health Organization (WHO) emphasized the importance of lockdown between countries and individuals as social distancing (Atalan, 2020; Stein, 2020). Such measures proved to be very helpful in terms of limiting virus transmission but the restriction on mobility, socialization, and in general changes of everyday lifestyle led to other kinds of problems (Znazen et al., 2021).

Due to the lockdown academic institutions also had to change the method of education and switch to online teaching. The students' life became even more challenging as together with bearing the stress caused by the pandemic and lockdown, they had to get adapted to the online learning pattern, (Di Pietro et al., 2020). Recent evidences prove that all these pandemic associated situations impacted students' academic achievements, mental and psychological stress, concentration, motivation, general behavior, social relationships, food and sleep habits, etc. (Di Pietro et al., 2020; Espino-Díaz et al., 2020; Gewalt et al., 2022; Mbous et al., 2022; Znazen et al., 2021). Especially these could affect international students who are living abroad, away from families and feel less safe and supported in the host country (Mbous et al., 2022). Even though many studies investigated the impact of COVID-19 on students' life, there is very little research on international students.

In the frame of presented work the impact of COVID-19 pandemic on the cognitive functions was investigated in international students who were enrolled in Georgian Universities and who during the pandemic stayed in Georgia, or in their country of origin (mainly India) with their families. In general, stress is proven to affect cognitive abilities such as attention, memory and executive functions (Cibrian-Llenderal et al., 2018; Marin et al., 2011). Recent evidence shows that stress during the pandemic significantly affects the cognitive functions of students during online learning (Quintiliani et al., 2021). Moreover, it is shown that stress level is higher in international students even before the pandemic (Alharbi & Smith, 2018; Fritz et al., 2008).

The main aim of presented work was to determine the state of such cognitive functions as attention, memory and executive functions during the pandemic in international students enrolled in Georgian universities. For that the performance of cognitive tasks were compared between two groups of international students: Group 1- students who stayed in Georgia during the pandemic and Group 2 – students who stayed with their families in their country of origin. According to previous evidences, it was expected that stress levels would be higher and cognitive performance would be declined for those international students who stayed away from their families (Group 1). Surprisingly, it appeared that the perceived stress level for both groups of students

³ rexbhas@gmail.com

⁴ khatuna.parkosadze@eeu.edu.ge

was similar (moderate), but cognitive performance for students who stayed with families (Group 2) was worst compared to that of the students who stayed in Georgia (Group 1).

Methodology

Participants

International students enrolled at different Georgian Universities were invited to participate in this study. Forty student volunteers were involved in total. None of them suffered from any known psychiatric or neurological disease as reported. All Participants had normal or corrected to normal vision and had no prior experience in the tasks used in this study. Students were assigned into two groups according to their place of stay during the pandemic: Group 1 – international students who stayed in Georgia during the pandemic (n = 20), and Group 2 – international students who stayed with their families in their country of origin (n = 20). Written and oral informed consent was provided prior to participation in the experiment. All procedures were conducted in accordance with the Declaration of Helsinki (2013).

Design and Procedure

The data was collected from August 2021 to April 2022. During that time period, there were mostly lockdowns in almost all countries and the same was for Georgia and India, with some transition periods in Georgia. The experiments were performed online via ZOOM or TEAMS platforms with all the tests well adapted for online use.

In this cross-sectional study, two questionnaires were completed and psychophysical tests for the evaluation of cognitive functions were performed. The Psychology Experiment Building Language (PEBL) program was used for running cognitive experiments (Mueller & Piper, 2014). Participants' demographic characteristics (age, gender, educational level, and academic achievement (GPA), infected by COVID-19) were collected via self-report in the general questionnaire.

The stress level of participants was evaluated via the **Perceived Stress Scale (PSS)** by Cohen (1983). Participants answered questions related to their subjective feelings during the last month. According to the answers, the score of stress perception is calculated as perceived stress being low (scores ranging from 0-13), moderate (scores ranging from 14-26) and high (scores ranging from 27-40).

The cognitive functions of participants were evaluated using the following psychophysical tests: Digit Span Tasks (forward and backward) (Elliott et al., 2011), Visual Search Task (Treisman, 1985; from the PEBL Psychological Test Battery), and Wisconsin Card Sorting Test (Grant & Berg, 1948; from the PEBL Psychological Test Battery).

Digit Span Task is a very good measure of attention, working memory (forward condition) and short-term memory (backward condition). In this task participants have to repeat the numbers (from 1 to 9) presented randomly at a rate of one per second; in the forward digit span condition participants are required to repeat the list in the same order as presented and in backward digit span condition participants are required to repeat the list in backward order. The list sequence began at a span of two numbers and in case of success, the sequence was increased. The longest sequence successfully recalled is recorded as performance level.

The visual selective attention was evaluated via a **visual search task**. In this task, participants were asked to search for a target (that could be one of the following: white O, white X, green O, or green X) presented among distracters (white letters). The number of distracters was different among the trials and was 10, 20, or 30 letters presented simultaneously. The percentage of correct answers as well as reaction times for correct responses were recorded and analyzed in order to evaluate visual selective attention. In general, a longer reaction time indicates deteriorated performance that is linked to a decline in attention (Shah et al., 2010; Treisman, 1985).

Wisconsin Card Sorting Test (WCST) measures general executive functions such as cognitive flexibility, planning, attention and working memory. In this task, 128 cards must be sorted according to shape, color or number of figures on the card. The Participants are not told according to which strategy they are supposed

to sort the cards, however feedback about whether or not cards were successfully sorted is given after each response to facilitate learning and performance. The following measures are reported and analyzed: the number of correct responses, the number of errors in general, the number of perseverative errors, the number of non-perseverative errors and the number of cards to complete the first category.

Statistical analysis

SPSS (IBM corp., Version 20.0) was used for statistical analysis. Descriptive statistics were performed for qualitative variables and are presented as mean $\pm$ standard deviation.

To compare the results of psychophysical experiments analysis of variance (One-Way ANOVA) was used. The percentage of correct responses was analyzed and in addition for visual search task reaction times were also compared. Reaction time was defined as the interval between the appearance of the search display and the button press as an indicator that the target was found. Responses faster than 350 milliseconds were categorized as „fast guesses, and responses slower than 5,000 milliseconds as „too slow and were rejected from analysis. Both of these categories hardly ever occurred (<1%). For all tests, the significance level was accepted as $p \leq 0.05$ and the confidence interval as 95%.

Results

Table 1 represents the demographic data of the participants in both groups. There was no significant difference in age and level of education (GPA) of participants ($p > 0.05$), but the GPA of students of group 2 was significantly higher than students of group 1 ($p < 0.05$). GPA was provided as a self-report and as reported was from the previous study year; accordingly, association of academic achievement and ongoing situation with each other is not appropriate. No significant difference was observed for perceived stress level (PSS) ($p > 0.05$). PSS level for both groups was moderate.

No significant difference was found in performance for Digit Span forward condition, $P > 0.05$ [$F(1, 37) = 1.057$, $p = 0.311$], as well as for backward condition, $P > 0.05$ [$F(1, 37) = 2.82$, $p = 0.101$] (figure 1). The performance of digit span is not different from the general results of the same task in young adults (Ebaid & Crewther, 2018).

Table 1. Demographic information of participants

Characteristics		Group 1 (n = 20) Mean $\pm$ SD	Group 2 (n = 20) Mean $\pm$ SD	F	df	P
Age		21.5 $\pm$ 1.8	22.2 $\pm$ 1.2	1.48	1	0.230
Gender, n (%)	Male	6 (30)	8 (40)			
	Female	14 (70)	12 (60)			
Level of education (semester)		6 $\pm$ 2.2	7 $\pm$ 2.4	2.53	1	0.120
Academic achievements (GPA)**		2.46 $\pm$ 0.5	2.97 $\pm$ 0.42	9.5	1	0.003
Covid 19, n (%)	NO	15 (75)	16 (80)	1.88	1	0.16
	YES	5 (25)	4 (20)			
PSS		18.4 $\pm$ 5.8	17.3 $\pm$ 3.9	0.65	1	0.423

** indicates that $p < 0.005$

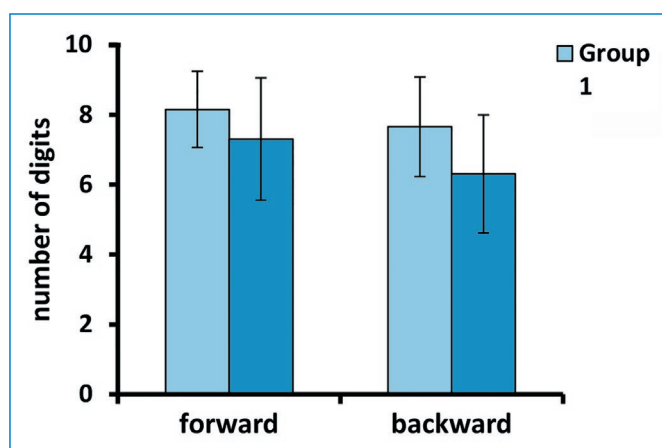


Figure 1. Performance of digit span test. There is no difference in performance for two groups and the results do not differ from literature evidences.

The performance of the Visual Search Test was not significantly different for the two groups ($P > 0.05$) (figure 2), but there was a significant difference in reaction times for second group students showing slower performance (figure 3). However, for both groups reaction time increased with an increased number of distracters and reaction time decreased for pop-out conditions (like green targets among white distracters). In general, increase in reaction time for both groups' participants compared to earlier evidence for the participants of the same age group was observed (Wong and Low, 2018). One can argue that such an increase in reaction time can be explained because of online performance of tasks, but again, evidences show that online performance increases reaction time for slight expense (Chetverikov, & Upravitelev, 2016). These results indicate that pandemic situation has affected attentional processes for students of both groups and students of second group more than first group students.

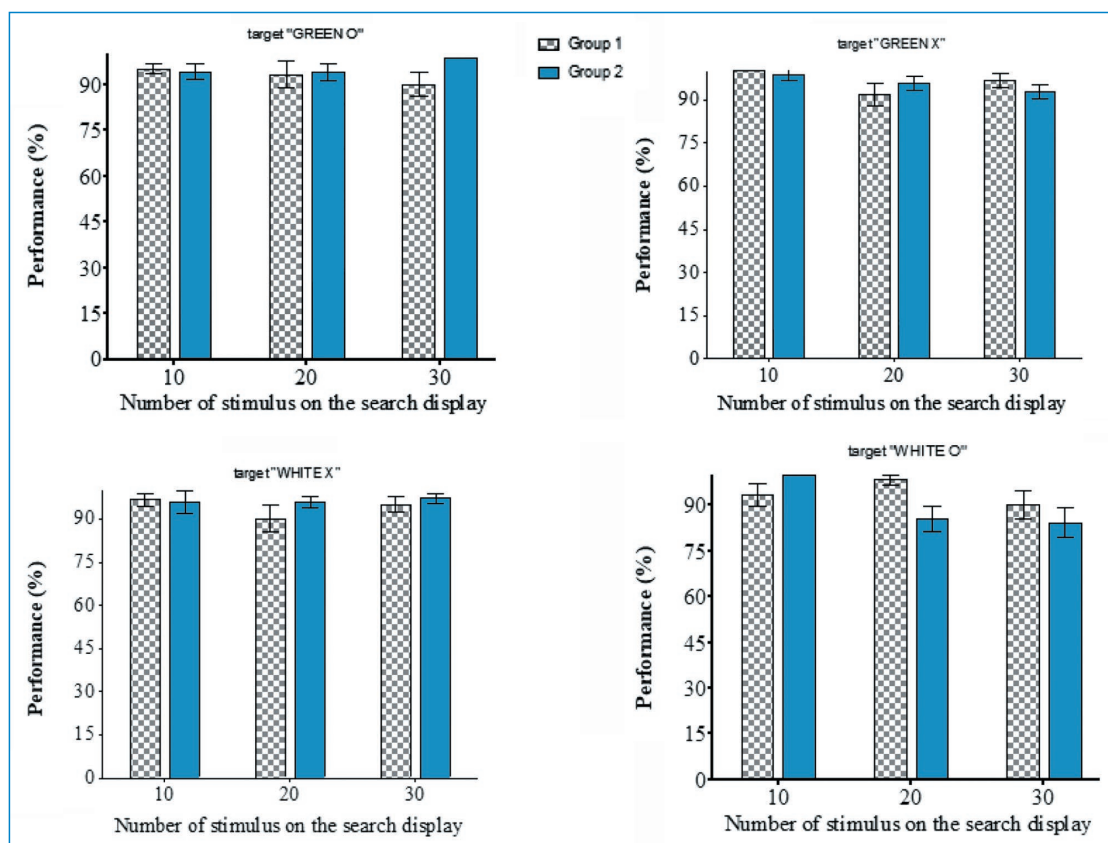


Figure 2. Performance of visual search task for both groups and for all types of search displays. There is no significant difference in task performance; participants of both groups performed the task with highest accuracy.

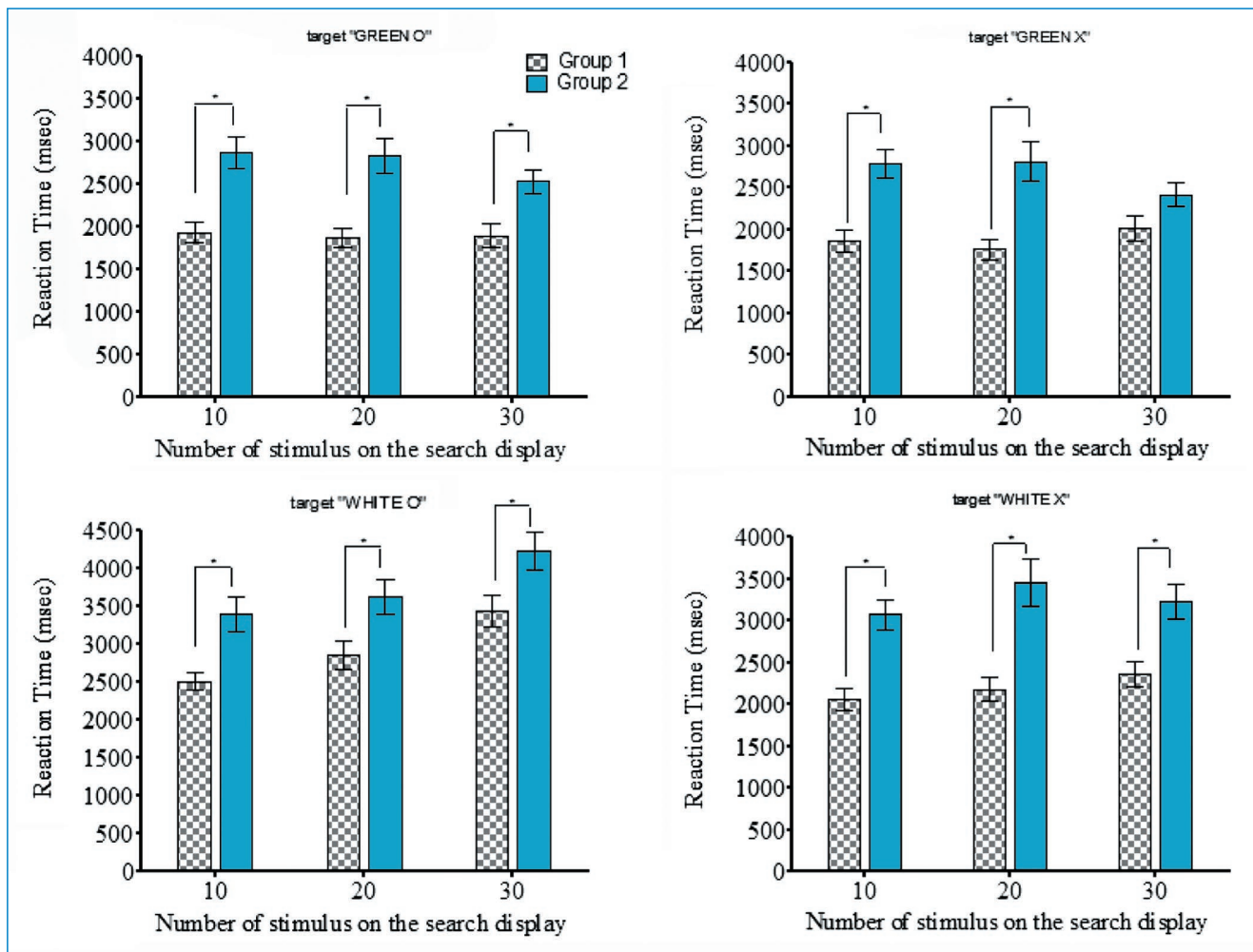


Figure 3. Reaction times for visual search task for both groups and for all types of search displays. Participants tasks were to search for White O [$F(1, 37) = 10, p = 0.003$], White X [$F(1, 37) = 20.42, p = 0.001$], Green O [$F(1, 37) = 19.6, p = 0.001$] and Green X [$F(1, 37) = 15, p = 0.000$].

Results of WCST are presented in table 2. There was no significant difference in the total number of correct responses between the two groups ($p > 0.05$) showing similar performance in general. The number of total errors, perseverative errors and non-perseverative errors showed a significant difference between the two groups ($p < 0.05$), indicating that executive functions deteriorated for students of group 2 more than for students of group 1.

Presented research is subject to some limitations that could account for the reported results. First of all the study was limited by small sample size – only 20 international students in each group were tested. Obviously more sample size would give more data and chance for correlational analysis that is not done now. Next, current study is cross-sectional study; hence it is not really possible to make comparisons with cognitive performance in pre-pandemic period. Better cognitive performance was found for the students of first group who had spent pandemic period in Georgia, possibility of such comparison (evaluation of cognitive functions before and during pandemic) would shed light reason why students of group 1 have better cognitive performance. The last limitation concerns the online testing procedure that could cause bias not only psychophysical test results, also performance of digit span test. Future studies including same participants and procedures done in offline situation would explore what actually is the condition of cognitive functions in international students enrolled in Georgian universities.

Table 2. Results of WCST performance

WCST	Group 1 Mean ± SD	Group 2 Mean ± SD	F	df	P
Correct responses	99 ± 3.8	99 ± 6.7	0.003	1	0.95
Total errors*	20 ± 6.7	26 ± 8.5	6.94	1	0.01
Perseverative Responses*	36.8 ± 6.7	41.95 ± 9	3.99	1	0.05
Perseverative errors**	13 ± 3.8	17.8 ± 6.3	7.72	1	0.008
Non-perseverative errors	6.95 ± 4.3	8.7 ± 3.2	1.98	1	0.16
Trials to complete 1st cat	14 ± 6	14 ± 4	0.015	1	0.9

* indicates that $p < 0.05$

** indicates that $p < 0.005$

Conclusions

Here cognitive functions (attention, working memory, executive functions) in two groups of international students enrolled in Georgian universities were investigated: Group 1 – international students who stayed in Georgia during the pandemic ($n = 20$), and Group 2 – international students who stayed with their families in their country of origin. The results showed that the perceived stress level is moderate for students of both groups. Attention, short-term and working memories evaluated with Digit Span Task are not affected and there is no significant difference in performance of those tasks between the two groups. However, selective attention and general executive functions are declined for students of the second group.

It is obvious that the pandemic situation affects international students similarly, yet it is not quite clear why cognitive functions are better in students who stayed in Georgia (away from families) compared to students who stayed at home with families. It can only be speculated that because the pandemic situation in India was worst at the time of testing that has also impacted general cognitive performance.

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