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Moderating the Neuropsychological Impact of Online Learning on Psychology Students

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Abstract: The purpose of the study was to identify what neuropsychological effect online learning had on psychology students and how it could be moderated. The study was descriptive and combined qualitative and quantitative methods to address the research questions. The study relied on three phases such as baseline study, experiment, and reporting. The experiment utilised neuropsychology tests adopted from the NeurOn platform. It was found that the Psychology students' perceptions of e-learning and their emotional reaction to them were found not to be appreciative. The practices in breathing exercises, meditation, or yoga were proved to be able to moderate the impact of online learning on the experimental group students' attentional capacities, memory processes, and cognition abilities. The above findings were supported by the results obtained for the neuropsychology tests and the experimental group students' self-reflections yielded from the use of the MovisensXS App. The students confirmed that breathing exercises, meditation, or yoga reduced study stress and burnout caused by e-learning and improved their academic performance. The focus group online discussion also showed that integration of breathing exercises, meditation, and yoga helped the experimental group students keep emotional balance, concentrate on their studies easier, remember more information, and meet deadlines in completing assignments. The education scientists are suggested to study how the e-learning curriculum could be reshaped so that it used relaxation practices on regular basis.

Keywords: *Higher education, neuropsychological impact, online learning, psychology students.*

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Introduction

A global pandemic has provided a never-before-seen boost to online learning and instruction in higher education (Jayalakshmi, 2021; Shahzad, et al., 2020). That sudden change led to an instructional and technological shift in learning science which is seen as a convergence of three fields such as neuroscience, education research, and cognitive psychology (Perdue, 2021). Rasheed et al. (2020) and Barrot et al. (2021) also relate that unforeseen enhancement of online learning to five challenges which are students' self-regulation skills, the technological literacy, and competency of both students and teachers, the isolation of students, technological sufficiency of institutions, students and teachers, and technological complexity of generating, shaping and measuring (assessing) knowledge. The above suggests that taking advantage of fully home-based online learning requires students to build resiliency skills, adopt new learning strategies across diverse learning contexts and technological means, and surmount challenges. However, recent studies show that fully home-based online learning causes mental health problems in students such as anxiety, frustration, and inconvenience (Copeland et al., 2021; Fagan, 2021; Marroquín et al., 2020). The college and university students complain about being forced to adjust to online learning which results in significant distress that affects their mood, thinking, and behaviours. These mental states and behaviours are related to brain activity and the rest of the nervous system, and these are studied within neuropsychology. The studies on the neuropsychological impact of online learning are still limited and the studies

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on the neuropsychological impact of online learning on preservice psychologists – those who are aware of how to adjust themselves to new learning setup – were not found. This inspired the research and created a gap to address.

Literature Review

The Psychological and Instructional Perspective of Online Learning

The literature reveals that a global pandemic challenged the approaches to perform the process of teaching-learning online (Barron et al., 2021; Lemoine et al., 2021; Zalat et al., 2021). American Psychological Association (APA), when highlighting the psychological perspective of the problem, emphasised the pronounced effects of the pandemic on students' mental health and wellbeing which hindered their educational attainment and outcomes (APA, 2020). Marziali and Lu (2021) reported the increased depression and anxiety rates amongst college and university students worldwide. Alam et al. (2021) found that computer-mediated learning and emotional intelligence caused substantial study stress and burnout in students which resulted in academic underperformance. Son et al. (2020) state that there is a need for developing psychological interventions and preventive strategies to cope with the effects that COVID-19 has on the mental health of college students.

Instructionally, the global pandemic is reshaping the online learning mode dramatically. The teachers move from face-to-face to technologised and individualised teaching. It was found the attempt to automate e-learning at higher education institutions. Lychuk et al. (2021) share their best practice of the use of automation of the teaching-learning process via the use of the Smart Sender Platform. Bobrytska et al. (2020) highlighted the benefits of the use of the *Dialogflow chatbot* in the Moodle LMS-based course. The automation of the instruction was reported to optimise the students' cognitive load, reduce the dropout rate, and increase learning engagement and motivation (Bobrytska et al., 2020; Lychuk et al., 2021). Ortiz and Levine (2021) presented their findings on fully online occupational training of psychology undergraduates which was reshaped to be delivered within the university-based counselling and assessment training centres that provide telehealth psychological services to the public.

Neuropsychology of Online Learning

Generally, the studies on the neuroscience of learning categorise learning into skill learning and intentional learning. Skill learning relies on long-term, semantic, implicit memory. Intentional learning is based on long-term, semantic, explicit memory. Both skill learning and intentional learning are functionally regulated by the frontal lobe of the brain. This area of the brain is proved to be influenced by digital learning (Belham, 2018; Bresciani Ludvik, 2016; Fred, 2020). In the above context, the neuropsychological assessment aims at assessing the entirely cognitive processes such as attention and concentration capacities, verbal and visual memory capacity, processing of auditory and visual information, visual-spatial functioning. It also tests language and reading skills, sensory development and integration, gross and fine motor development, development of social skills, executive functioning, and emotional and personality development of the individual (Neuro Assessment and Development Center, 2021).

The neuropsychology of online learning studies positive and negative influences of e-learning on learners. Jozefowiez (2012) indicates that the e-learning mode benefits students mentally – it fosters their ability to concentrate better, reduces peer pressure, ensures flexibility in the use of individualised intellectual stimuli by the instructor. However, it causes changes in the functioning of the brain and social cognition abilities in learners because of the increased multi-tasking, cognitive overload that leads to the overconsumption of metabolic energy (Firth et al., 2019). Firth et al. (2019) opine that e-learning negatively influences the social cognitive abilities of the learners. Takeuchi et al. (2018), and Loh and Kanai (2016) indicate that those changes in the brain - such as a reduction of volume of the cortex and a decrease of grey matter in the individual's prefrontal areas – lead to the impediment of the information processing speed of learners when they search, locate, and read the online content. Johnson (2020) argued that the e-learning mode that was conducted throughout a pandemic imposed stress on the students. That stress caused them to release stress hormones such as adrenaline, norepinephrine, and cortisol which impaired students' brain functions related to learning. Liu et al. (2018) found that the verbal intelligence and visual system of the learners are also impacted by the e-learning mode of study. Since, online learning has proved to cause emotional disorders, such as depression or anxiety, it seems to be the very case when medical practitioners recommend administering neuropsychological tests to figure out the preventive measures (Bhargava, 2020).

The literature review found no research on the neuropsychological impact of online learning on Psychology students. Therefore, the purpose of the study is to identify what neuropsychological effect online learning has on psychology students and how it can be moderated.

The research questions are as follows:

a) how students perceive their e-learning experiences
b) how the practices in breathing exercises, meditation, or yoga moderate the impact of online learning on students' attentional capacities, memory processes, and cognition abilities
c) how the experimental group students perceive the intervention.

Methodology

The study was descriptive and combined qualitative and quantitative methods to address the research questions (McLeod, 2019). It lasted from October 2020 till June 2021. The study relied on three phases such as baseline study, experiment, and reporting. The baseline study phase attempted to answer the research question concerning students' perceptions of their distance learning experiences. This research phase relied on the survey data yielded with the questionnaire that was designed by the authors (see Appendix A). The experiment utilised neuropsychology tests adopted from NeurOn (NeurOn, 2021). These instruments were chosen because they were digitalised, recommended for both clinicians and researchers, and used by a number of well-established institutions which proved that they were reliable. The tests were used to measure experimental group students' attentional capacities, memory processes, and cognition abilities before and after the intervention. In the experimental phase, the study also used the experience sampling method (Larson & Csikszentmihalyi, 2014). This was to involve the sampled students in the reporting on their thoughts, feelings, and behaviours in different settings such as before doing their studies online, after the classes, after they practiced breathing exercises, meditation, or yoga. The data were collected using the MovisensXS App for Android smartphones (Movisens, 2021). In this phase, the focus group online discussion was also administered to address the third research question which aimed at exploring the experimental group students' perceptions and attitudes towards the intervention. The Otter automatic speech-to-text transcription application was used to process the participants' responses to the questions (Otter, 2021). The reporting phase involved data systematical consolidation and organisation so that data could be interpreted and analysed by the research team.

The Design of the Experiment

The study used a quasi-experimental design. Its experiment part was a flow of five steps. These were as follows: 1) completing the screening form (see Appendix B); 2) forming the experimental group (EG) and control group (CG) each consisting of 25 students; 3) pre-intervention measurements - administration of the nine online tests such as Alternate Tapping (AT) Test, Cancellation Test, Star Counting Test, Spatial Working Memory Test – Backwards, Sustained Attention to Response Test, Trail Making A Test, Picture Encoding Test, Picture Recognition Test and Digit Span – Backwards on the NeurOn platform; 4) involvement of EG students in performing breathing exercises, meditation, and yoga for 15 min before and after the online classes. Along with these, they reported on their thoughts, feelings, and behaviours in different settings using the MovisensXS App for Android smartphones (See Fig. 1).

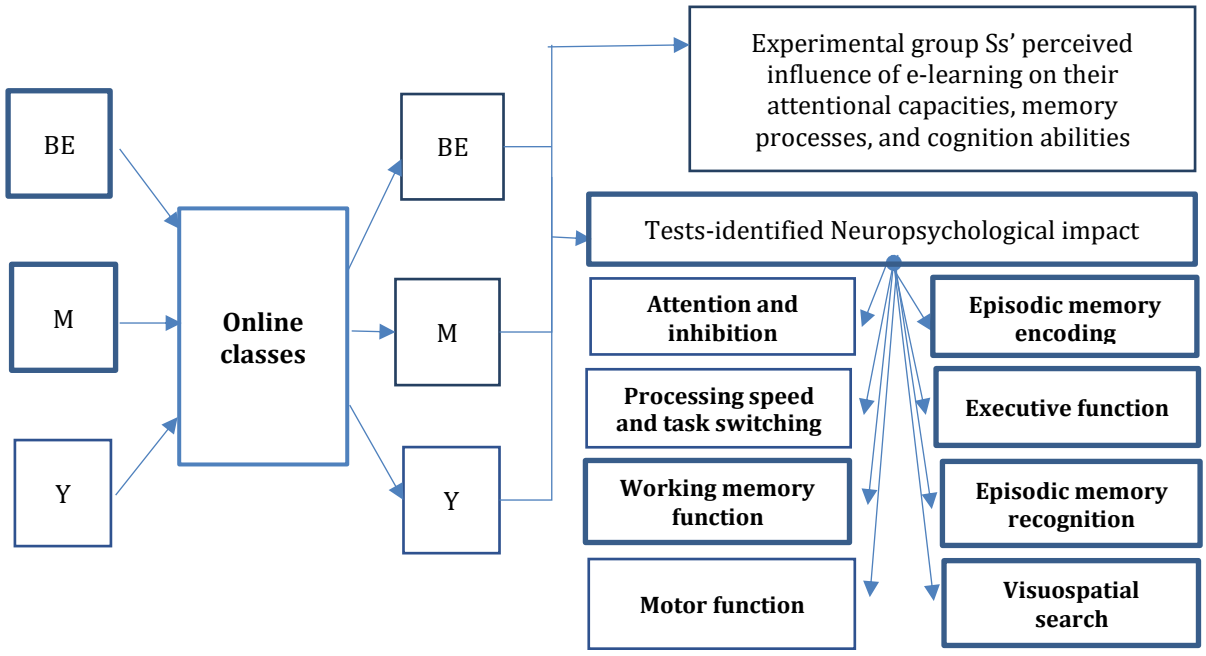

Figure 1. Abstract Instruction Management Scheme to Reduce the Neuropsychological Impact of Online Learning of the Psychology Students (Note: BE - Breathing exercises; M – Mediation; Y – Yoga)

Importantly, the CG performed their e-learning as they commonly did. 5) after-intervention measurements - after the semester the nine online neuropsychological tests are administered again. These were as follows: Simple Reaction Time (SRT) Test, Fragmented Letter Test, Virtual Supermarket Test, Spatial Working Memory Test – Forwards, Sustained Attention to Response Test, Trail Making B test, Word Encoding Test, Word Recognition Test, and Digit Span – Backwards Test.

Sampling

The random sampling technique was used in the baseline study phase. In this phase, the link to a survey questionnaire on how students perceive their e-learning experiences was sent to 249 university students majoring in Psychology at National Pedagogical Dragomanov University (NPDU) (Ukraine), Borys Grinchenko Kyiv University (BGKU) (Ukraine), State University of Infrastructure and Technologies (SUIT) (Ukraine) and National Aviation University (NAU) (Ukraine). Seventy-six responses were excluded from the analysis because they either lacked students' consent or reported students' specific health problems. The demographic features of the respondents are presented in Table 1.

Table 1. Demographic Features of the Respondents Surveyed in the Baseline Study (n=173)

Demographic features		NPDU	BGKU	SUIT	NAU	Mean	SD
Age	18-19	21 (26.25%)	22 (27.50%)	18 (22.50%)	19 (23.75%)	18.60	0.489
	20-21	16 (28.57%)	15 (26.78%)	12 (21.42%)	13 (23.22%)	20.39	0.488
	22-23	12 (32.43%)	9 (24.32%)	11 (29.72%)	5 (13.52%)	22.59	0.490
Gender	Males	13 (25.49%)	17 (33.33%)	12 (23.52%)	9 (17.64%)	12.75	2.861
	Females	31 (25.41%)	34 (27.86%)	28 (22.95%)	29 (23.77%)	30.50	2.291

The convenience sampling method was used to select undergraduates from National Pedagogical Dragomanov University (NPDU) and State University of Infrastructure and Technologies (SUIT) to participate in the experiment. The sampling procedure for the intervention used the Screening Form (see Appendix B) designed by the Department of Psychology for National Pedagogical Dragomanov University. The link to the form was shared with the students through the Viber and Telegram messengers. It also included information about the purpose of the experiment and addressed ethical consideration requirements. Additionally, the students were informed that participation in the intervention earned them additional credit points in the Psychology course. Importantly, the form served as the set of selection filters to discover which of the students are eligible to participate in the intervention as well. Those criteria were as follows: a) the age was expected to be between 19 and 21; b) right-handed; c) not suffering from any hearing problems, or neurological difficulties, or movement limitations or mental handicaps; d) not diagnosed with any learning disability of neurological nature, or attention-deficit/hyperactivity disorder, or psychiatric illness. Fifty undergraduates aged 18-21 ($M = 19.56$, $SD = 0.98$) were selected to form the experimental group (EG) and control group (CG) each consisting of 25 people. The EG group involved 25 students for National Pedagogical Dragomanov University (NPDU) and the CG consisted of 25 undergraduates majoring in Psychology for State University of Infrastructure and Technologies (SUIT). The homogeneity of both groups in academic efficiency was identified by calculating the grade point average (GPA). The GPA value for the EG was 3.47 and it was 3.52 for the CG which meant that the groups could be considered comparable. The pre-intervention measurements were also administered using neuropsychology tests which proved that the groups were homogeneous.

Ethical Considerations

The sampled students were sent Letters of Information and Consent to Participate in a Research Study. By these, the students were provided with the information that revealed the purpose and procedure, estimated outcomes, and possible discomforts or risks associated with practicing breathing exercises, meditation, or yoga in the educational intervention. Following that, the students signed the consent form to indicate that they made the informed decision to enter into the study at the intervention point. Any personal information and students' identity were only accessed by the research team to ensure confidentiality and anonymity. The draft of the survey questionnaire on how students perceived their e-learning experiences was examined several times to ensure that it did not consist of discriminatory or offensive wording (Goodwin et al., 2019).

Instruments

The study addressed the research questions through the use of the survey questionnaire on how students perceived their e-learning experiences, a set of neuropsychology tests, and the focus group online survey. The data that were collected with the survey and tests were analysed using the *Jamovi* computer software (Version 2.0.0) (Jamovi Project, 2021).

Survey Questionnaire on How Students Perceive their E-learning Experiences

The questionnaire, which is in Appendix A, and can be accessed via the link https://forms.gle/jqaMQQWoRU1o9jGx8, consisted of 23 close-ended questions to cover the demographic features of the respondents including information about their health problems that they were aware of, their perceived attentional capacity, perceived learning success in e-learning settings, perceived study load and perceived emotional states. Questions 12 to 23 used the Likert 5-point rating scales such as "Frequency Scale", "Degree of difficulty scale". The face validity, construct validity, content validity and the inter-rater reliability of the questionnaire were performed following Rodrigues et al. (2017) and Taherdoost (2016). The content validation was performed by five members of the research team and three volunteer colleagues. The value for

the item-level content validity index (IL-CVI) was 0.836. This was greater than the critical value (0.75) for the number of experts like this and meant "good agreement". The face validity and construct validity of the questionnaire were also found by the experts as good and appropriate for the study (Taherdoost, 2016). The inter-rater reliability was performed by five raters – three members of the research team and two volunteer colleagues – who used the 4-point relevance scale. The Fleiss's Kappa coefficient was 0.640 which meant "substantial agreement" of the raters on the relevance of questions in the questionnaire (Polit & Beck, 2006). The questionnaire was set up with Google Forms and then administered to university students. A psychometrist was hired to interpret some results of the survey.

Neuropsychology Tests

The study used a set of neuropsychology tests designed by the NeurOn team (NeurOn, 2021). The tests were administered online at pre-experimental and post-experimental phases in both EG and CG. The instrument comprised 16 tests. These were as follows: 1) Alternate Tapping Test (based on the B.R.A.I.N test), 2) Cancellation Test, 3) Digit Span – Backwards, 4) Fragmented Letter Test, 5) Picture Encoding Test, 6) Picture Recognition Test, 7) Simple Reaction Time Test, 8) Spatial Working Memory – Backwards, 9) Spatial Working Memory – Forwards, 10) Star Counting Test, 11) Sustained Attention to Response Test, 12) Trail Making A Test, 13) Trail Making B Test, 14) Virtual Supermarket Test, 15) Word Encoding Test, 16) Word Recognition Test. The distribution of tests is shown in Table 2.

Table 2. Tests Used at Pre-Experimental and Post-Experimental Phases and Brain Functions They Cover

Brain function	Pre-experimental phase	Post-experimental phase
Motor function	Alternate Tapping (AT) Test	Simple Reaction Time (SRT) Test
Visuospatial search	Cancellation Test (CT) Star Counting Test (SCT)	Fragmented Letter Test (FLT) Virtual Supermarket Test (VST)
Working memory function	Spatial Working Memory Test – Backwards (SWMT-B)	Spatial Working Memory Test – Forwards (SWMT-F)
Attention and inhibition	Sustained Attention to Response Test (SART)	Sustained Attention to Response Test (SART)
Processing speed and task switching	Trail Making A Test (A-test)	Trail Making B Test (B-test)
Episodic memory encoding	Picture Encoding Test (PET)	Word Encoding Test (WET)
Episodic memory recognition	Picture Recognition Test (PRT)	Word recognition test (WRT)
Executive function	Digit Span – Backwards (DS)	Digit Span – Backwards (DS)

Overall, the tests are cross-sectional and cover participants' attentional capacities, memory processes, and cognition abilities. The AT test and SRT test are both used with the same purpose – to test participants' motor functions. Both tests calculate scores for how well each hand of the participant manifests kinesia, bradykinesia, akinesia, dysmetria, and incoordination. The tests aim to identify any movement disorder. The visuospatial search tasks – the Cancellation Test, the Star Counting Test, the Fragmented Letter Test, and the Virtual Supermarket Test – are to diagnose an early visual disorder in participants. The Spatial Working Memory Test – Backwards and the spatial working memory test – Forwards are based on the Corsi block test (Berch et al., 1999). The tests provide the data on fronto-parietal cortex functioning. The Sustained Attention to Response Test (SART) is supposed to detect the frontal lobe symptoms in participants through testing their attention and higher executive functions. The Trail Making A & B Tests are to identify the participants' processing speed and task switching, as well as their attentional resources and motor function. The tests that are used to identify the encoding and memory performance – the episodic memory encoding test and the word encoding test – are based on the tasks that are related to memorising a series of everyday high-frequency words, which are then displayed on some side of the computer screen. The participants' episodic memory recognition is tested through the Picture Recognition Test and Word Recognition Test. Both tests aim at identifying contextual or source memory for the memorised words. The Digit Span Test – Backwards is to examine the higher executive and working memory functions of the participants which are related to the performance of their frontal lobe zones. The testing system provides the statistical results for the tests as an Excel file instantly. In the context of the study, the neuropsychology tests were accepted as the ones that were validated by default by the NeurOn team.

Focus Group Online Discussion Questions

Nine randomly selected EG students were selected to participate in the focus group online discussion. It relied on 5 open-ended questions and took more than an hour. The questions were as follows:

1) How do you feel overall about integrating breathing exercises, meditation, yoga into online studies at university? Suggest examples to illustrate your experience.

2) Can you describe your positive and negative experiences of participation in the updated model of online studies at university? What caused, if any, negative impressions, and how they can be addressed in the future? Provide your reasoning.

3) What, in your view, were the purposes of integrating breathing exercises, meditation, yoga into online studies? Did they help you concentrate, remember, and process information more efficiently? Suggest examples to illustrate your answers.

4) Do your think the integration of breathing exercises, meditation, yoga into online studies at universities can help in coping with the negatives of e-learning?

5) How the teaching model that is based on the use of breathing exercises, meditation, yoga in online studies can be made more student responsive?

Three research team members moderated and facilitated the discussion. Other research team members transcribed it using the Otter speech-to-text application. The students' responses were coded and analysed. The procedure of identifying the coding reliability was performed in accordance with Syed and Nelson (2015). It relied on the data-driven approach which was supposed to use the construction of a coding scheme that was based on the collected data. The verbatim interview transcript was then divided into the interview question-related themes. The draft of a coding manual was designed. Two coders, who were graduates from Borys Grinchenko Kyiv University and State University of Infrastructure and Technologies, were randomly selected and trained to use the coding manual to avoid confusing interpretations. The coders coded the data individually, then they met for the consensus meeting online. Following that, the Cohen's Kappa reliability coefficients were calculated. The index value for inter-coder reliability was 0.655 meaning 'substantial agreement' between the raters.

Results

The study attempted to address three research questions. The first research question was aimed at identifying how students perceived their e-learning experiences. The purpose of the second research question was to identify how the practices in breathing exercises, meditation, or yoga influence students' attentional capacities, memory processes, and cognition abilities while they perform online learning. The third question was addressed via the focus group discussion that was intended to find how the experimental group students perceive the intervention.

Results Drawn from the Baseline Study

The data yielded for the survey were analysed manually and using the *Jamovi* computer software (Version 2.0.0). Since the questionnaire consisted of filter questions and questions to collect the demographic data, the further analysis only used the data that answered the first research question. The analysis reveals the students' perceptions of their suitability for e-learning, study workload, e-learning aspects, and their emotional reaction to them. The analysis of Q7 and Q8 suggested that 75.4% of the respondents were sure that they were suitable students for the e-learning and 64.3% of students were certain that they did their best to be successful in e-learning. More than two-thirds (68.4%) of the surveyed students reported that they spent 5-6 hours daily on online classes and 54.7% of the students showed that they spent the same amount of time on doing assignments. The psychometrist, who was hired to interpret the collected data, proved that the students over limited time on their studies. The descriptive statistics for the questions that used Likert scales are presented in Table 3.

Table 3. Descriptive Statistics Drawn from the Survey for the Questions That Used Likert Scales

			95% Confidence Interval		SD	Skewness		Shapiro-Wilk	
	Mean	SE	Lower	Upper		Skewness	SE	W	P
Q6	1.91	0.0561	1.80	2.02	0.738	0.5776	0.185	0.914	< .001
Q11	2.30	0.0403	2.22	2.38	0.530	0.8553	0.185	0.875	< .001
Q12	3.90	0.0560	3.79	4.01	0.737	-0.1078	0.185	0.936	< .001
Q13	3.69	0.0522	1.59	1.79	0.687	0.4946	0.185	0.874	< .001
Q14	2.65	0.0555	2.54	2.76	0.729	0.1116	0.185	0.942	< .001
Q15	1.84	0.0467	1.75	1.94	0.614	0.1015	0.185	0.869	< .001
Q16	3.79	0.0500	3.69	3.89	0.658	0.2491	0.185	0.885	< .001
Q17	1.83	0.0481	1.73	1.92	0.632	0.1556	0.185	0.878	< .001
Q18	1.55	0.0474	1.46	1.64	0.623	0.6861	0.185	0.932	< .001
Q19	1.53	0.0516	1.42	1.63	0.678	1.1488	0.185	0.920	< .001
Q20	1.57	0.0500	1.47	1.67	0.657	1.3442	0.185	0.911	< .001
Q21	3.84	0.0548	3.73	3.95	0.721	0.0655	0.185	0.927	< .001
Q22	4.32	0.0498	4.23	4.42	0.655	-0.4515	0.185	0.869	< .001
Q23	3.97	0.0528	3.87	4.07	0.694	0.0385	0.185	0.905	< .001

As can be seen in Table 3, the Mean values for every question skewed either left or right which meant students' negative perception. The value for Q6 (M=1.91, SD=0.0561) indicated that the students rated their experience with online learning as the one that 'did not meet their expectations at all' or 'somewhat met their expectations'. Concerning Q11, the values (M=2.30, SD = 0.0303) implied that students considered the assessment to be the one that lacks transparency and is confusing or too strict. The responses to Q12 (M=3.90, SD=0.0560) showed that students were often worried about their academic performance when they study online and they had a difficult time with controlling their study workload (Q13 – M=3.69, SD=0.0522, and Q16 – M=3.79, SD=0.0500). The respondents could just sometimes meet deadlines, according to values for Q14 (M=2.65, SD=0.0555) and they needed the effort to control their irritation during online classes that caused stress (Q15 – M=1.84, SD=0.0467, and Q17 – M=1.83, SD=0.0481). The values for Q18, Q19, Q20, Q21, Q22, and Q23 suggested that the respondents faced difficulties with concentration and speed of processing information (Q18 - M=1.55, SD=0.0474, Q19 – M=1.53, SD=0.0516, Q20 – M=1.57, SD=0.0500, Q21 – M=3.84, SD=0.0548, Q22 – M=4.32, SD=0.0498, Q23 – 3.97, SD=0528).

The above data suggested that the biology of the learning and brain capacity needed change and this inspired the use of breathing exercises, meditation, yoga in the online studies to address the issues.

Intervention

The ANCOVA test was used to measure how the practices in breathing exercises, meditation, or yoga moderate the impact of online learning on the EG students' attentional capacities, memory processes, and cognition abilities were based on neuropsychology tests. The results of the pre-test measurements were used as a covariate. The results of the analysis are presented in Table 4.

Table 4: Results of Measurements Performed Before and After the Intervention based on the ANCOVA test, EG ($n = 25$), and CG ($n = 25$)

ANCOVA – Post-test	Sum of Squares	df	Mean Square	F	p	η^2	ω^2
Overall model	17940	2	8969.9	152.4	< .001		
Pre-test	16885	1	16884.5	286.9	< .001	0.897	0.891
Treatment	1055	1	1055.2	17.9	< .001	0.056	0.053
Residuals	883	15	58.8				

As can be seen in Table 4, the value for the proportion of the variability (η^2) for the Pre-test and Post-test tends to be 1 meaning that the relationship between the two is sufficient, $\eta^2 = 0.897$ (Navarro & Foxcroft, 2021). Furthermore, it could be deemed by Cohen's guidelines that the value for treatment ($\eta^2 = 0.056$) showed a medium effect size with 5.6% of the variance caused by the intervention independent variable (Eddy, 2010). As detailed in the Post Hoc Comparisons Table (see Table 5), the Mean Difference values ($M_{difference}$ = −15.3, SE = 3.62) proved that there was an improvement in the brain functioning of the EG students due to the use of breathing exercises, meditation, yoga in e-learning.

Table 5. Post Hoc Comparisons Based on Mean Values Drawn from Neuropsychological Tests

Comparison		Mean Difference	SE	df	t	p	$Cohen's\ d$	95% Confidence Interval	
Treatment	Treatment							Lower	Upper
As usual	Intervention	−15.3	3.62	15.0	−4.23	< .001	−2.00	−3.27	−0.726

Note. Comparisons are based on estimated marginal means

The t-value ($t\ (25) = -4.23$; $p = < .001$) also implied that the EG students experienced a more significant improvement in their motor function, visuospatial search, working memory function, attention and inhibition, processing speed and task switching, episodic memory encoding, and recognition, and executive function. The effect size was also significant, $Cohen's\ d = -2.00$, which supported the assumption that the practices in breathing exercises, meditation, or yoga moderate the impact of online learning on the EG students' attentional capacities, memory processes, and cognition abilities.

The above data were supported by the EG students' self-reflections yielded from the use of the MovisensXS App. They confirmed that breathing exercises, meditation, or yoga reduced study stress and burnout caused by e-learning and moderated their academic performance.

Focus Group Online Discussion

Question 1. The students reported that integrating breathing exercises, meditation, and yoga helped them keep emotional balance, concentrate on their studies easier, remember more information, and meet deadlines in completing assignments. Some illustrative quotes were as follows:

> *'…before I started breathing exercises prior and after the classes, it was hard for me to focus and retain information but then I became confident that I can manage all these assignments in time…'*
>
> *'…since I did a part-time job, my life was getting more and more difficult. I was about to quit my job so that I could study, but yoga changed me dramatically. Now I feel motivated to do my online classes and assignments…'*
>
> *'… I thought my study workload was unaffordable and unmanageable, but after a month of regular 30-minute meditation I processed information twice as fast as before and my study workload seemed just OK to me …'*
>
> *'… before taking part in the experiment I spent 8-9 hours a day on my assignments and I was furious, anxious, sleepy, and very tired of learning and literally wring down all the lectures I attended. After two months of doing yoga before and after the classes, the studies took me just 3-5 hours a day and I remembered the lectures far better…'*

Question 2. The students mentioned that they gained self-control of their thoughts, emotions, and learning efforts as their positive experiences and the need for training teachers in the use of technology as their negative experiences. The students' quotes were as follows:

> *'... I remember the delay with my grades for the completion of the module. After two weeks, my groupmates were in a panic, but me. I could control myself and help others…'*
>
> *'… in the middle of the online course the number of assignments has increased substantially, I could hardly manage deadlines… My friends were frustrated, but I felt sure that I could deal with this… Yoga and breathing activities worked for me…'*
>
> *'… some professors had problems with using online tools. Sometimes they used too many which distracted me and made me lost in the course. …it was a crap…'*
>
> *'... I often felt as if I was teaching myself…'*
>
> *'… it would be better if the lecturers record their lectures and I had the opportunity to watch them several times at my convenience …'*

The students suggested training lecturers in online teaching and assessment to make it more transparent and less strict because these cause the greatest proportion of frustration.

Question 3. The student's view of the purpose of integrating breathing exercises, meditation, yoga into online studies was to influence the biology of learning and memory. They made sure that breathing exercises, meditation, yoga had helped them study more efficiently. Below are some students' quotes:

> *'… I was striving for excellence in my studies but I had a difficult time concentrating and retaining information. Now, I feel I can do twice as much…'*
>
> *'… I search and analyse information faster and more efficiently than I did before …'*

Question 4. Students' responses to this question suggest that they support the idea of integration of breathing exercises, meditation, yoga into online studies at universities in the way these activities were used in the experiment. They stated that those activities can help the students to deal with the visual impairment, difficulties with concentration, and cognitive activity which they had when studying online.

Question 5. The most frequent suggestions in participant responses were as follows: a) introduction of yoga or meditation schools for students; b) launching information campaigns aimed at popularising using breathing exercises, meditation, yoga in online studies; c) creating channels on YouTube and TikTok to share students' experiences in practicing the above activities.

Discussions

The study attempted to gain a better understanding of, first, how students perceived their e-learning experiences, second, how the practices in breathing exercises, meditation, or yoga moderated the impact of online learning on students' attentional capacities, memory processes, and cognition abilities, and third, how the experimental group students perceived the intervention.

The novelty of the study lies in the approach to monitoring students' biology of the learning and brain capacity using the recently developed online tools which allow making the university study process more students responsive. One more strength of the study is in the use of breathing exercises, meditation, or yoga moderate the impact of online learning on students' attentional capacities, memory processes, and cognition abilities.

The study found that the students' perceptions of their suitability for e-learning, study workload, e-learning aspects, and their emotional reaction to them were not appreciative. The analysis of Q7 and Q8 suggested that 75.4% of the respondents were sure that they were suitable students for the e-learning and 64.3% of students were certain that they did their best to be successful in e-learning. More than two-thirds (68.4%) of the surveyed students reported that they spent 5-6 hours daily on online classes and 54.7% of the students showed that they spent the same amount of time on doing assignments. These were interpreted as the over-limit of time spent by students on their studies. The Mean values for every question skewed either left or right which meant students' negative perception. The value for Q6 (M=1.91, SD=0.0561) indicated that the students rated their experience with online learning as the one that 'did not meet their expectations at all' or 'somewhat met their expectations'. Concerning Q11, the values (M=2.30, SD = 0.0303) implied that students considered the assessment to be the one that lacks transparency and is confusing or too strict. The responses to Q12 (M=3.90, SD=0.0560) showed that students were often worried about their academic performance when they study online and they had a difficult time with controlling their study workload (Q13 – M=3.69, SD=0.0522, and Q16 – M=3.79, SD=0.0500). The respondents could just sometimes meet deadlines, according to values for Q14 (M=2.65, SD=0.0555) and they needed the effort to control their irritation during online classes that caused stress (Q15 – M=1.84, SD=0.0467, and Q17 – M=1.83, SD=0.0481). The values for Q18, Q19, Q20, Q21, Q22, and Q23 suggested that the respondents faced difficulties with concentration and speed of processing information (Q18 - M=1.55, SD=0.0474, Q19 – M=1.53, SD=0.0516, Q20 – M=1.57, SD=0.0500, Q21 – M=3.84, SD=0.0548, Q22 – M=4.32, SD=0.0498, Q23 – 3.97, SD=0528).

The most compelling explanation for the above set of findings could be that the surveyed students were under academic pressure which the respondents associated with unreasonably excessive cognitive overload, limited flexibility, and emotional problems and fears. This pattern of results is consistent with Alam et al. (2021), Johnson (2020), and Bhargava (2020) who opine that in pandemic settings e-learning causes study stress, burnout, and decline in students' academic performance. The above results provided supporting evidence of impaired students' brain functioning related to learning which was found by Johnson (2020).

One more key finding of the study is that the practices in breathing exercises, meditation, or yoga moderate the impact of online learning on the EG students' attentional capacities, memory processes, and cognition abilities. The value for the proportion of the variability (η^2) for the Pre-test and Post-test tends to be 1 meaning that the relationship between the two is sufficient, $\eta^2 = 0.897$. Furthermore, it could be deemed by Cohen's guidelines that the value for treatment ($\eta^2 = 0.056$) showed a medium effect size with 5.6% of the variance caused by the intervention independent variable (Eddy, 2010). The Post Hoc Comparisons found that the Mean Difference values ($M_{difference}$ = –15.3; $SE = 3.62$) indicated an improvement in the brain functioning of the EG students due to the use of breathing exercises, meditation, yoga in e-learning. The t-value (t = – 4.23; $p = < .001$) also implied that the EG students experienced a more significant improvement in their motor function, visuospatial search, working memory function, attention and inhibition, processing speed and task switching, episodic memory encoding, and recognition, and executive function. The effect size was also significant, $Cohen's\ d = -2.00$ which supported the assumption that the practices in breathing exercises, meditation, or yoga moderate the impact of online learning on the EG students' attentional capacities, memory processes, and cognition abilities.

The above data were supported by the EG students' self-reflections yielded from the use of the MovisensXS App. They confirmed that breathing exercises, meditation, or yoga reduced study stress and burnout caused by e-learning and improved their academic performance. The focus group online discussion also confirmed that integration of breathing exercises, meditation, and yoga helped the EG students keep emotional balance, concentrate on their studies easier, remember more information, and meet deadlines in completing assignments.

The above data have an intervention-related implication such as the development of emotional stability in young people which seems relevant in the settings of a computer-mediated learning environment. The implication is consistent with Alam et al.'s (2021), Barron et al. (2021), Hatzichristou et al. (2021), Pedditzi and Spigno (2019), and Quiroz et al., (2020) who found that there was a need for training students in controlling and mitigating stress situations and students lacked learning strategies that help them keep themselves mentally healthy. The study agrees with Bhargava (2020) who claimed that the administration of neuropsychological tests to young people to figure out the preventive measures is desirable. The present research, therefore, contributes to a growing body of evidence suggesting that digital learning affects brain functioning (Belham, 2018; Bresciani Ludvik, 2016; Fred, 2020). An immense of work remains to be done before a full understanding of the extent of influence of digital learning on learners' brains is established.

Conclusion

The Psychology students' perceptions of e-learning and their emotional reaction to them were found not to be appreciative. The practices in breathing exercises, meditation, or yoga were proved to be able to moderate the impact of online learning on the experimental group students' attentional capacities, memory processes, and cognition abilities. The above findings were supported by the results obtained for the neuropsychology tests and the experimental group students' self-reflections yielded from the use of the MovisensXS App. The students confirmed that breathing exercises, meditation, or yoga reduced study stress and burnout caused by e-learning and moderated their academic performance. The focus group online discussion also showed that integration of breathing exercises, meditation, and yoga helped the experimental group students keep emotional balance, concentrate on their studies easier, remember more information, and meet deadlines in completing assignments.

Recommendations

The practitioners are recommended to take a course or training in breathing, meditation, or yoga for at least half a year before they train students. They are also supposed to get aware of neuropsychology tests provided by NeurOn and learn to interpret the data they provide. The education scientists are suggested to study how the e-learning curriculum could be reshaped so that those integrated relaxation practices on regular basis. The avenue of further research could be on what preventive effect the optimised curriculum could have on students in terms of fatigue, predisposition to emotional disorders caused by the distance learning mode.

Limitations

The students' access to technology to complete the survey questionnaire, to take the NeurOn tests, and to use the MovisensXS App, as well as the availability of reliable internet could be relevant limitations to the study. The application of criteria such as age, right-handedness, health issues imposed some more limitations to the study. Students' major – Psychology, and the convenience sampling method that was used to select undergraduates for the study were likely to be a limitation.

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Conflicts of Interest

The authors declare having no conflict of interest of any nature.

Authorship Contribution Statement:

Voloshyna: Concept and design, data acquisition, data analysis/interpretation, drafting manuscript, critical revision of the manuscript, and statistical analysis. Stepanenko: Technical support, supervision, data acquisition, data analysis/interpretation. Zinchenko: Drafting manuscript, and critical revision of the manuscript. Andriiashyna: Data acquisition, data analysis/interpretation, and final approval. Hohol: Data acquisition, drafting manuscript, critical revision of the manuscript, and final approval.

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Appendices

Appendix A. Survey questionnaire on how students perceive their e-learning experiences (https://forms.gle/jqaMQQWoRU1o9jGx8)

1. Your age _____
2. Your gender _____
3. Are you left or right-handed?
    a) left-handed
    b) right-handed
4. Have you ever, or are you currently suffering from, had any of the below:
    a) hearing problems
    b) neurological difficulties
    c) movement limitations or mental handicaps
    d) none of the above
5. Have you ever been diagnosed with any of the below:
    a) learning disability of neurological nature
    b) attention deficit/hyperactivity disorder
    c) psychiatric illness
    d) none of the above
6. How would you rate your experience with online learning?
    a) does not meet my expectations at all
    b) somewhat meets my expectations
    c) just as I expected
    d) better than I expected
7. Do you consider yourself to be a suitable student for e-learning?
    a) Yes
    b) No
8. Are you certain that you do your best to be successful in e-learning?
    a) Yes
    b) No
9. How much time do you typically spend on online classes a day?
    a) 1-2 hours
    b) 3-4 hours
    c) 5-6 hours
    d) more
10. How much time do you typically spend on home assignments a day?
    a) 1-2 hours
    b) 3-4 hours
    c) 5-6 hours
    d) more
11. How do you feel about the assessment?
    a) It is fair
    b) It lacks transparency and is confusing
    c) It is too much strict
    d) It is OK for me
12. How often do you worry about your academic performance when you study online?
    a) never
    b) rarely
    c) sometimes
    d) often
    e) always
13. How often do you feel that you are unable to control your study workload?
    a) never
    b) rarely
    c) sometimes
    d) often
    e) always
14. How often do you manage meeting deadlines?
    a) never
    b) rarely

c) sometimes
d) often
e) always

15. How often do you fail to control your irritation during online classes?
a) never
b) rarely
c) sometimes
d) often
e) always

16. How often do you delay the assignments or feel to be in a rush so that they were fulfilled on time?
a) never
b) rarely
c) sometimes
d) often
e) always

17. How stressful has online learning been for you since the pandemic started?
a) very stressful
b) somewhat stressful
c) neither stressful nor stressless
d) somewhat stressful
e) not stressful at all

18. How easy is it for you to combine ideas from a number of different areas when you study online?
a) not easy at all
b) not easy
c) neither easy nor difficult
d) somewhat easy
e) absolutely easy

19. How quick are you at analysing a complex situation that occurs in your online studies?
a) not quick at all
b) somewhat quick
c) neither quick nor slow
d) somewhat quick
e) super quick

20. How difficult is it for you to concentrate when people talk to you?
a) very difficult
b) somewhat difficult
c) neither difficult nor easy
d) somewhat easy
e) absolutely easy

21. How much are you distracted by the sights and sounds when you study online?
a) not distracted at all
b) somewhat distracted
c) I am OK
d) somewhat distracted
e) absolutely distracted

22. How often do feel confused and forgetful because you have so many things on your mind when doing the courses online?
a) never
b) rarely
c) sometimes
d) often
e) always

23. How often do you feel that you make mistakes in online classes because you watch what others do and forget about yourself?
a) never
b) rarely
c) sometimes
d) often
e) always

Appendix B. Screening form to select students for the EG and CG (can be accessed at: https://forms.gle/erxxcNaiAvkJDmyz9)

By answering the questions below, you provide your consent to participate in the research experiment on the neuropsychological impact of online learning on Psychology students. In this way, you also provide your agreement to the research team to process and use your personal information for research purposes. We would be grateful if you answer each question as accurately as possible.

1. Your age _____
2. Your gender _____
3. Are you left or right-handed?
    a) left-handed
    b) right-handed
4. Have you ever, or are you currently suffering from, had any of the below:
    a) hearing problems
    b) neurological difficulties
    c) movement limitations or mental handicaps
    d) none of the above
5. Have you ever been diagnosed with any of the below:
    a) learning disability of neurological nature
    b) attention-deficit/hyperactivity disorder
    c) psychiatric illness
    d) none of the above