STRESS: A DOUBLE-EDGED SWORD IN DIGITAL LEARNING

LO STRESS: UN'ARMA A DOPPIO TAGLIO NELL'APPRENDIMENTO DIGITALE

Francesca Argentino[1]
University of Camerino, School of Advanced Studies, Camerino, Italy;
Pegaso University, Faculty for Human Sciences, Naples, Italy
francesca.argentino@unicam.it
0009-0003-2172-266X
Leila Ali[2]
University of Camerino, School of Advanced Studies, Camerino, Italy;
Pegaso University, Faculty for Human Sciences, Naples, Italy
leila.ali@unicam.it
0000-0003-4437-0014
Luigi Barrea[3]
Pegaso University, Faculty for Human Sciences, Naples, Italy;
luigi.barrea@unipegaso.it
0000-0001-9054-456X

Double Blind Peer Review

Citazione

Argentino F., Ali L., Barrea L., (2023) Stress: a double-edged sword in digital learning, Giornale Italiano di Educazione alla Salute, Sport e Didattica Inclusiva - Italian Journal of Health Education, Sports and Inclusive Didactics. Anno 7, V 2. Edizioni Universitarie Romane

Doi:
https://doi.org/10.32043/gsd.v7i2.853

gsdjournal.it
ISSN: 2532-3296
ISBN: 978-88-6022-470-5

ABSTRACT

In this study, the relationship between digital learning and stress and its impact on learning is investigated, analysing empirical studies available in literature. Stress has always been considered as a negative side effect of digital use, but recently a positive link between stress hormones and cognition arose. The idea of a resourceful balance emerged, with specific stress levels promoting learning. Future research is needed to analyse the digital impact on cognition in the educational field.

Si esplora il legame tra apprendimento digitale e stress e il suo impatto sull'apprendimento tramite l'analisi di studi empirici disponibili in letteratura. Lo stress è considerato un effetto collaterale dell'uso di strumenti digitali, ma di recente è emerso un legame positivo con l'apprendimento. Si ipotizza che esista un equilibrio in cui livelli specifici di stress promuovano l'apprendimento. Studi futuri sono necessari per analizzare l'impatto digitale sulla cognizione nel campo educativo.

KEYWORDS
digital learning, stress, cortisol
apprendimento digitale, stress, cortisolo

Received 15/04/2023
Accepted 22/04/2023
Published 20/05/2023

Introduction[1]

The new digital evolution revolutionised learning. Access to digital tools for learning has become easier and more approachable for everyday life. Digitalisation emerged in the classroom first as a complementary tool for classical learning. It got more powerful recently after the Coronavirus Disease (COVID-19) pandemic but has been proposed as an alternative modality for the classical classroom learning for many years (Moore et al., 2011). Digital learning has been defined by the University of Edinburgh as an «innovative use of digital tools and technologies during teaching and learning» (*What Is Digital Education?*, 2018). There are multiple digital learning forms available nowadays; they include virtual learning based on the use of information and communication technologies (ICTs), blended learning (combining virtual and classical classroom learning), and learning based on other digital instruments like gamification, virtual reality, social networking, 3D printing, and intelligent tutoring systems. These digital tools are providing a more flexible learning environment (Ødegaard et al., 2021) in terms of learning interests, motivation, access to science, affordability, and they are opening up new perspectives about personalised learning (Vivekananda & Ruvn, 2017). This increased exposition to digital tools came at a cost of concerns about their possible impact on physical and psychological health. Some of these concerns are related to stress and anxiety. Stress is defined in biological terms as the physiological and endocrine changes that the body uses as a response to a stimulus (Yaribeygi et al., 2017). This reaction aims often at maintaining homeostasis, activating the body's fast reactions, and providing a state of optimal performance of all the organs as a response to a potential threat (Vogel & Schwabe, 2016). Stress endocrine reactions are mediated by the autonomic nervous system (ANS) with the release of catecholamines, responsible of the "fight or flight" response (Tsigos et al., 2000). This leads to a cascade of events within the hypothalamic-pituitary-adrenal (HPA) axis (Swaab et al., 2005) and results in the release of other hormones, mainly corticosteroids, among which cortisol is the most important end-product. These

[1] This study is the result of a joint collaboration between the authors.
[1,2]Francesca Argentino and Leila Ali wrote the paragraphs "Introduction", "Methods", "Discussion", "Digital tools used for learning", "Digitalisation and the brain" and "Conclusions".
[3]Luigi Barrea wrote the paragraph "Stress, stress hormones and cognition in education" and edited the scientific review of the study.

stress hormones act through different receptors to generate complex responses within different organs, including the brain. Their impact on the brain involves multiple regions, among which those interfering with cognitive functions like attention, and memory (Vogel & Schwabe, 2016). This impact on cognition can be both negative and beneficial.

It is within this spectrum that lies the purpose of this study. The aim is to understand and meditate on the relationship between exposition to digital tools for learning and stress hormones and to study the impact of stress on cognition and learning in light of the latest research available in literature.

Methods

This narrative review explored how digitalisation interferes with stress levels, and how stress hormones impact learning and cognitive functions, in the educational environment. This purpose was fulfilled by analysing the different available empirical studies in literature focusing on stress and exposition to digital tools. The following keywords was used to conduct this bibliographical research on platforms like PubMed and ResearchGate: “stress”, “stress hormones”, “cortisol”, “digital learning”, “digital use”.

Discussion

Technology is revolutionising the world and every aspect of our everyday life. It was only a matter of time before it was implemented into the educational field. This implementation is still ongoing, and modernising teaching methods, strategies and designs. In the field of digitalisation, literature’s main focus was about the impact of using digital tools on the brain. This impact on the brain concerns many aspects like cognitive functions, social functions, sleep quality, consciousness, and also stress. This study’s main interrogation is on how this massive use and availability of digital devices can impact the body’s hormonal balance when it comes to stress and how stress responses can evolve from a simple response to a physical “threat”, to an adaptive mechanism of the massive and continuous exposition to digital

instruments. Stress in basic conditions is also known to have beneficial effects and also drawbacks. How can digital tools interfere and alter these dynamics?

The scope of this study is to answer these questions from the available results of recent empirical studies on digitalisation and stress. Therefore, this review is divided in three sections. In the first section, there is the description of the different available digital tools used for learning. In the second section, the aspect of how different stress hormones impact cognition and learning is explored. Finally, the last section focuses on the effects of digitalisation on the brain and how digital use can interfere with brain development, visual fatigue, sleep cycle and cognitive functions. The interrelationship with stress and digitalisation is described as well.

1. Digital tools used for learning

Typologies of devices used in digital learning span from computers, to smartphones and tablets, to interactive whiteboards, and even to augmented reality technologies in the most advanced situations. Each of these tools is characterised by potential benefits and disadvantages in their educational purpose. The advantages are represented by the immediacy with which the educational concepts can be transmitted to students – for example, using videos or even augmented reality leads to a better understanding of concepts that may be difficult to assimilate if only explained by words. However, the novelty of these techniques could pose some challenges to the learners, especially the older ones, thus putting them in stressful and anxiety-inducing situations. Teachers should be trained in the utilisation of digital devices in order to optimise their educational purpose, but also to be able to assist those who may be not acquainted with information and communication technologies (ICTs).

2. Stress, stress hormones and cognition in education

The tight relationship between stress and learning has been studied thoroughly. In fact, stress increases learning and memory performances compared to neutral situations. This can be observed in the study of fear learning, where fear and anxiety induce an increase in stress hormones' circulation, and stimulate learning and

memorisation (Merz & Wolf, 2022). There is a critical temporal correlation between the stress hormonal cascade, cognitive processes, and the type of hormones secreted. In fact, a rise in catecholamines' or glucocorticoids' concentration will exert different effects on the process of memorising a certain event based on the difference in temporal proximity (Vogel & Schwabe, 2016). On top of that, their release has different outcomes for the three distinct stages of memorisation, i. e., encoding, consolidation and retrieval (Fig. 1). In particular, catecholamines – mostly (nor)epinephrine – are rapidly activated by the ANS and appear to strengthen synapses in the hippocampus, thus promoting encoding (Katsuki et al., 1997). Cortisol, on the other hand, is slowly released in the blood stream by the HPA axis. Thus, it influences cognitive functions at different timeframes, while still fostering learning and memory during the encoding and consolidation phases (Merz & Wolf, 2022). When it comes to retrieval in episodic memory, stress hormones were found to hamper the recalling of encoded material. Different studies, however, reported variable outcomes when it comes to learning under stressful conditions (Smeets et al., 2008), mostly because there are multiple influencing factors interfering with learning that should be considered like stress stimuli and the different learning mechanisms and environments.

	Catecholamines	**Corticosteroids**
Effects on memory encoding	*At the time of the stressful event:* improve memory encoding *After the stressful event:* impair memory encoding	*At the time of the stressful event:* improve memory encoding *After the stressful event:* impair memory encoding
Effects on memory consolidation	Improve memory consolidation	Improve memory consolidation
Effects on memory retrieval	*At the time of the stressful event:* improve memory retrieval *After the stressful event:* impair memory retrieval	*At the time of the stressful event:* improve memory retrieval *After the stressful event:* impair memory retrieval

Figure 1 (The relationship between a rise in stress hormones and the performances in the three stages of memory formation is characterised by a strict temporal correlation.)

3. Digitalisation and the brain

- *Digitalisation and cognition*

With the ongoing digital evolution, a large portion of the general population – especially the older generations – started to worry about the effects of the constant use of technological devices on human health. Some significant connections emerged when scientists researched the impact of these devices on brain structures and function. For instance, the link between technology use and attention problems has been investigated. Even though results are still unclear, the typical repetitive attentional shifts related to digital – i. e. online – use was observed to be related to impaired executive functions (Small et al., 2020). This can be explained by the tendency towards multitasking of digital users. While this may be commonly considered as a useful skill, studies show that it actually reduces the attention span (Nikkelen et al., 2014). Another aspect worth mentioning is the recent recognition of the technology addiction. Even though it is not formally yet included in the Diagnostic and Statistical Manual of Mental Disorders (Battle, 2013), the excessive use of digital tools is considered as a pathological experience caused by the hyperstimulation of the dopaminergic system derived from the near-constant inputs coming from technological devices. This addiction has a different prevalence in each part of the world. The highest rates were registered in the Middle East (Small et al., 2020). Symptoms include easy mood changes, preoccupation, and even impairments in the functional sphere (Young, 1996). A more thorough comprehensive assessment of all the possible brain alterations caused by technology use is yet to be obtained, since digital devices are relatively new, and should be considered as a priority for future research. This impact should consider the short- and long-term effects, and should be performed on a large populations scale.

- *Digitalisation and brain development*

Excessive screen time exposition was reported to cause complications related to brain development during the early stages of life. Studies showed that prolonged screen time causes more damage in younger people, especially children and adolescents (Khan et al., 2022; Small et al., 2020). Children are advised to spend less than one hour a day with digital screens, because prolonged exposition can decrease their wellbeing, impair their ability to complete tasks and also affect their curiosity (Twenge & Campbell, 2018). Prolonged screen time exposition in childhood also alters the integrity of the white brain matter. Mainly, the connectivity between brain regions involved in language and cognitive control is affected (Horowitz-Kraus & Hutton, 2018). This results in linguistic impairments regarding fluency and/or comprehension.

- *Digitalisation and screen time: impact on sleep and visual fatigue*

The definition and assessment methods of sleep disorders are extremely variable. Therefore, it is difficult to indicate a clear prevalence of the abnormal sleep phenomena. Yet, it is estimated that the percentages range from 4% to 26% in the general population (Ohayon, 2011). These disturbances are within a variety of syndromes like insomnia, excessive sleepiness, etc. Their aetiology is yet to be fully understood. However, it is well-known that spending too much time in front of a screen can disrupt the sleep cycle. This is due to blue lights emissions that can interfere with the circadian rhythm (Small et al., 2020). In turn, problems in the sleep schedule can also cause behavioural and cognitive alterations. This aspect has been extensively investigated during and after the COVID-19 pandemic, when lockdown measures lead to more online connectivity, and as a result to sleep, emotional and behavioural variations (Picca et al., 2021). Blue light emissions can also cause “digital eye strain” or “visual fatigue”, characterised by tiredness of the eye, pain in/behind the eyes, vision impairment (e.g., blurred vision), dry eyes, and headache (Sheppard & Wolffsohn, 2018). This syndrome affects people of all age, and is particularly noticed to reduce productivity for office workers after long screen exposition times. Visual fatigue can be influenced by brightness and brightness contrast of the display. This means that the lower the brightness, the less is the discomfort and stress to the eyes, while higher brightness contrast allows a better visual experience (Tian et al., 2022).

- *Digitalisation and stress in learning: a potential helpful balance*

As a matter of fact, digital tools are related to a wide range of potentially harmful side effects (Fig. 2). These can all be linked to higher levels of stress in individuals. Despite this consideration, stress itself is one of the most difficult conditions to investigate, because it is dynamic and often considered as too broad to be accurately measured. There are different proposed methods for evaluating stress levels. These include self-report questionnaires (particularly useful to highlight psychological stress related to recalling traumatic life events), and other quantitative methods like measuring the heart rate variability (HRV) that records the fluctuation in length of heartbeat intervals (Kim et al., 2018). When stress occurs, the ANS is in an altered state, and heartbeats are controlled by the ANS. Therefore, the HRV can be an approximate measure to assess stress levels. In particular, HRV is lower after a stressful stimulus and higher in homeostatic conditions, meaning that heartbeats are closer in time to one another when the subject is in a stressful situation. Recent studies showed that also measuring brainwaves with electroencephalogram (EEG) can be used as a stress biomarker (Saeed et al., 2020). Finally, as already mentioned above, the body reacts to a stressful situation by releasing hormones that act to restore the homeostasis. Therefore, another way to measure stress is to assess cortisol levels via urine or blood sample. Alternatively, hair cortisol concentration (HCC) has been found to be a helpful tool to study long-term stress levels (Leppänen et al., 2020).

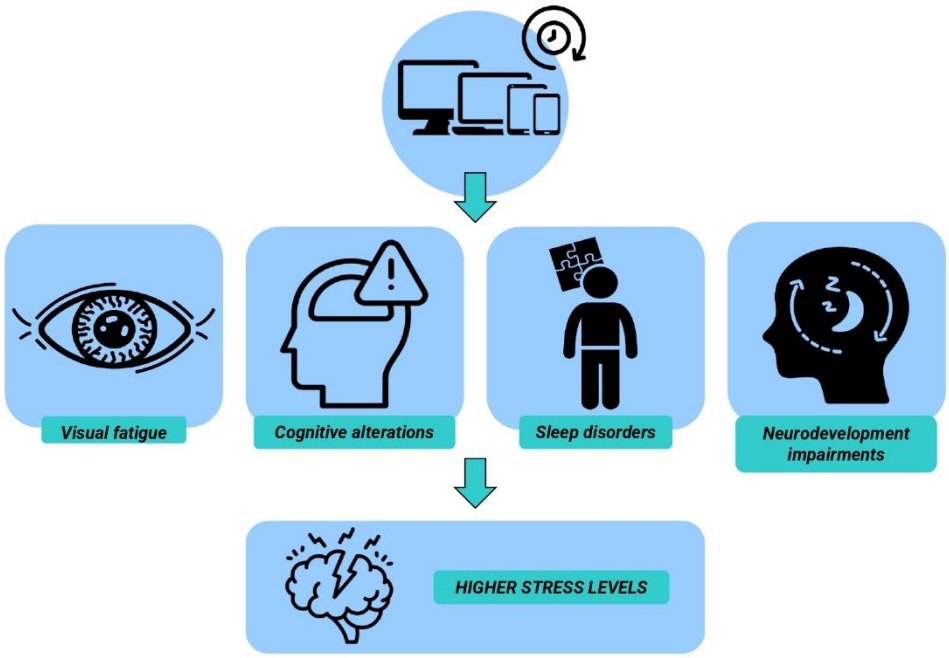

Figure 2 (Technology use for prolonged periods of time can result in a wide series of side effects, regarding the domains of eye health, cognitive functions, sleep cycle, brain development; these collateral effects can be referred to higher levels of stress. This figure includes icons downloaded from the website https://thenounproject.com/: “Digital devices” (created by TkBt from Noun Project), “History” (created by firdaus husyaeni from Noun Project), “Eye Strain” (created by Carl Holderness from Noun Project), “Mental Disease” (created by Berkah Icon from Noun Project), “Normal Child” (created by Gan Khoon Lay from Noun Project), “Sleep” (created by Victoruler from Noun Project), “Stress” (created by WEBTECHOPS LLP from Noun Project).)

There is an important study in the field of stress and learning that showed that light stress is associated with better performances in learning environments (Vogel & Schwabe, 2016). Given the documented relationship between screen time exposition and stress for technology users, and considering the digital shift in educational methods, interrogations are on whether or not learners are being put in uncomfortable and stressful situations at the school environment. In fact, given their digital aspect or not, learning contexts are frequently stressful both for students and teachers. It is therefore important to underline how digital devices

can impact these dynamics and to which level these frameworks can be problematic both in their physiological and psychological aspects. On the other hand, the digitalisation of learning has revolutionised education and improved learning quality and content in terms of accessibility and personalisation. This aspect is very important to consider since a more comfortable learning environment is possibly linked to reduced stress and anxiety, and to a better academic performance. The concept of a helpful balance between "bad stress" – the one that impairs learning and memory and results in different health impairments – and "good stress" – the one that stimulates cognitive functions – in a digitalisation perspective of the education system is important to highlight. In fact, posing stimulating challenges to students is an example of "good stress" that may enhance learning. However, increased pressure can result in a memory impairment both for encoding and recall. These observations highlight the importance of performing additional studies that consider the different educational contexts and the digital instruments used to precisely define the "range" in which stress can sort positive or negative effects on cognition. A "balance" between too much stress and too little (e.g., unchallenging and unstimulating teaching methods) could ensure the safety and efficacy of the relatively novel digital learning methods, shifting the focus on the students and their wellbeing. It is also important to find objective measures and tools to manage the exposition to digital devices in the learning field. Exposition to screens can for example be measured in terms of duration, time of exposition during the day, type of digital tool used, and settings of the display (e.g., screen brightness, colour contrast, etc.). Regarding the duration, young people nowadays spend around eight hours a day using digital media tools, not counting the time related to schoolwork (Haddock et al., 2022). Since fatigue and eye strain get worse with this increased screen exposition, longer and more frequent breaks for rest should be considered for students experiencing distance learning.

Conclusions

This review described the main digital devices used in education and how they can be classified into computers, smartphones, tablets, interactive whiteboards, and augmented reality technologies. Then, the relationship between stress hormones and cognition in education was analysed. It was shown how recent studies have revealed that catecholamines – and mainly norepinephrine – strengthen episodic

memory by increasing synaptic plasticity of hippocampal neurons. A dynamicity between the HPA axis stress hormones and cognition also emerged, without clear evidence on the positive or negative impact of this dynamicity on memories. Therefore, further studies should be performed about learning under stress considering the different hormonal measures, their interconnection, and their circadian and seasonal rhythms. Finally, the impact of digitalisation on the educational field was studied, along with how important they are in answering students' teaching needs and also the related challenges of their unsupervised use.

Digital teaching techniques can improve the quality and promote the sustainability of education. However, they can have extensive negative impacts on wellbeing if used for too long periods of time. One of these negative impacts is related to how they induce stress and maintain it. The recent findings about the link between stress and learning and the stressful consequences of digitalisation are of extreme usefulness in the educational field. Stress has always been considered as a negative situation to avoid, especially in learning contexts. Nonetheless, research evidence clarified further that the dynamics are more complex, and that the interrelationship between stress and learning requires a certain balance. This can have major implications on the educational field, considering the endlessly evolving scenario of the educational methodologies and designs, that are becoming always more technological. It is important to consider the different circumstances in learning, and how a decent amount of stress can be sometimes necessary to improve learning performances. The hypothesis of the useful balance between "good" and "bad" stress should be obtained, in order to maximize the performances of individuals in the educational context and optimise their learning experience, avoiding the ever-present complication of the educational relapses.

This narrative review is not without certain limitations. The bibliographical research included only articles in English and Italian, due to language constraints. Moreover, there is a lack of studies regarding the different effects of the different digital tools used in learning contexts on cognition and stress levels. Future studies will be needed to evaluate the impact of technology on cognition in educational environments and to validate the hypothesis that digital-induced stress does not overcome the many benefits of digital learning. The future challenges for the education system are to find ways to monitor stress levels in students, for example preparing periodic self-report questionnaires about the perceived stress levels, the potential symptoms of eye strain and sleep disorders, and measuring cognitive work-load through certain brain computer interfaces. Moreover, students should be aware of the effects that stress can exert on their educational life – as well as on

their everyday life – and they should be given the appropriate knowledge about the possible coping mechanisms. A good management is necessary to obtain a balance while using these ever-developing devices. It will help maximise both the learning performance and school neuro-ergonomics, and decrease the possible short- and long-term drawbacks for the student and the teacher.

References

Battle, D. E. (2013). Diagnostic and Statistical Manual of Mental Disorders (DSM). *CoDAS*, *25*(2). https://doi.org/10.1590/s2317-17822013000200017

Haddock, A., Ward, N., Yu, R., & O'Dea, N. (2022). Positive Effects of Digital Technology Use by Adolescents: A Scoping Review of the Literature. *International Journal of Environmental Research and Public Health*, *19*(21), 14009. https://doi.org/10.3390/ijerph192114009

Horowitz-Kraus, T., & Hutton, J. S. (2018). Brain connectivity in children is increased by the time they spend reading books and decreased by the length of exposure to screen-based media. *Acta Paediatrica (Oslo, Norway : 1992)*, *107*(4). https://doi.org/10.1111/apa.14176

Katsuki, H., Izumi, Y., & Zorumski, C. F. (1997). Noradrenergic regulation of synaptic plasticity in the hippocampal CA1 region. *Journal of Neurophysiology*, *77*(6). https://doi.org/10.1152/jn.1997.77.6.3013

Khan, A., Lee, E.-Y., & Horwood, S. (2022). Adolescent screen time: Associations with school stress and school satisfaction across 38 countries. *European Journal of Pediatrics*, *181*(6), 2273–2281. https://doi.org/10.1007/s00431-022-04420-z

Kim, H.-G., Cheon, E.-J., Bai, D.-S., Lee, Y. H., & Koo, B.-H. (2018). Stress and Heart Rate Variability: A Meta-Analysis and Review of the Literature. *Psychiatry Investigation*, *15*(3), 235. https://doi.org/10.30773/pi.2017.08.17

Leppänen, M. H., Sääksjärvi, K., Vepsäläinen, H., Ray, C., Hiltunen, P., Koivusilta, L., Erkkola, M., Sajaniemi, N., & Roos, E. (2020). Association of screen time with long-term stress and temperament in preschoolers: Results from the DAGIS study. *European Journal of Pediatrics*, *179*(11), 1805–1812. https://doi.org/10.1007/s00431-020-03686-5

Merz, C. J., & Wolf, O. T. (2022). How stress hormones shape memories of fear and anxiety in humans. *Neuroscience & Biobehavioral Reviews*, *142*, 104901. https://doi.org/10.1016/j.neubiorev.2022.104901

Moore, J. L., Dickson-Deane, C., & Galyen, K. (2011). e-Learning, online learning, and distance learning environments: Are they the same? *The Internet and Higher Education*, *14*(2), 129–135. https://doi.org/10.1016/j.iheduc.2010.10.001

Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J. (2014). Media use and ADHD-related behaviors in children and adolescents: A meta-analysis. *Developmental Psychology*, *50*(9). https://doi.org/10.1037/a0037318

Ødegaard, N. B., Myrhaug, H. T., Dahl-Michelsen, T., & Røe, Y. (2021). Digital learning designs in physiotherapy education: A systematic review and meta-analysis. *BMC Medical Education*, *21*. https://doi.org/10.1186/s12909-020-02483-w

Ohayon, M. M. (2011). Epidemiological Overview of Sleep Disorders in the General Population. *Sleep Medicine Research*, *2*(1), 1–9. https://doi.org/10.17241/smr.2011.2.1.1

Picca, M., Manzoni, P., Milani, G. P., Mantovani, S., Cravidi, C., Mariani, D., Mezzopane, A., Marinello, R., Bove, C., Ferri, P., Macchi, M., & Agostoni, C. (2021). Distance learning, technological devices, lifestyle and behavior of children and their family during the COVID-19 lockdown in Lombardy: A survey. *Italian Journal of Pediatrics*, *47*(1), 203. https://doi.org/10.1186/s13052-021-01156-8

Saeed, S. M. U., Anwar, S. M., Khalid, H., Majid, M., & Bagci, U. (2020). EEG Based Classification of Long-Term Stress Using Psychological Labeling. *Sensors (Basel, Switzerland)*, *20*(7). https://doi.org/10.3390/s20071886

Sheppard, A. L., & Wolffsohn, J. S. (2018). Digital eye strain: Prevalence, measurement and amelioration. *BMJ Open Ophthalmology*, *3*(1), e000146. https://doi.org/10.1136/bmjophth-2018-000146

Small, G. W., Lee, J., Kaufman, A., Jalil, J., Siddarth, P., Gaddipati, H., Moody, T. D., & Bookheimer, S. Y. (2020). Brain health consequences of digital technology use. *Dialogues in Clinical Neuroscience*, *22*(2), 179–187. https://doi.org/10.31887/DCNS.2020.22.2/gsmall

Smeets, T., Otgaar, H., Candel, I., & Wolf, O. T. (2008). True or false? Memory is differentially affected by stress-induced cortisol elevations and sympathetic

activity at consolidation and retrieval. *Psychoneuroendocrinology*, *33*(10). https://doi.org/10.1016/j.psyneuen.2008.07.009

Swaab, D. F., Bao, A.-M., & Lucassen, P. J. (2005). The stress system in the human brain in depression and neurodegeneration. *Ageing Research Reviews*, *4*(2), 141–194. https://doi.org/10.1016/j.arr.2005.03.003

Tian, P., Xu, G., Han, C., Zheng, X., Zhang, K., Du, C., Wei, F., & Zhang, S. (2022). Effects of Paradigm Color and Screen Brightness on Visual Fatigue in Light Environment of Night Based on Eye Tracker and EEG Acquisition Equipment. *Sensors (Basel, Switzerland)*, *22*(11). https://doi.org/10.3390/s22114082

Tsigos, C., Kyrou, I., Kassi, E., & Chrousos, G. P. (2000). Stress: Endocrine Physiology and Pathophysiology. *PubMed*. https://pubmed.ncbi.nlm.nih.gov/25905226/

Twenge, J. M., & Campbell, W. K. (2018). Associations between screen time and lower psychological well-being among children and adolescents: Evidence from a population-based study. *Preventive Medicine Reports*, *12*. https://doi.org/10.1016/j.pmedr.2018.10.003

Vivekananda, M., & Ruvn, S. (2017). *EMERGING TRENDS OF E-LEARNING IN INDIA*. *4*(6).

Vogel, S., & Schwabe, L. (2016). Learning and memory under stress: Implications for the classroom. *Npj Science of Learning*, *1*(1), 16011. https://doi.org/10.1038/npjscilearn.2016.11

What is digital education? (2018, September 14). The University of Edinburgh. https://www.ed.ac.uk/institute-academic-development/learning-teaching/staff/digital-ed/what-is-digital-education

Yaribeygi, H., Panahi, Y., Sahraei, H., Johnston, T. P., & Sahebkar, A. (2017). The impact of stress on body function: A review. *EXCLI Journal; 16:Doc1057; ISSN 1611-2156*. https://doi.org/10.17179/EXCLI2017-480

Young, K. S. (1996). Psychology of computer use: XL. Addictive use of the Internet: a case that breaks the stereotype. *Psychological Reports*, *79*(3 Pt 1). https://doi.org/10.2466/pr0.1996.79.3.899

April, 13rd 2023