Oshada; Jurnal Kesehatan
https://nawalaeducation.com/index.php/O/index
Volume 2 Nomor 2, April 2025
e-ISSN : 3047-017X
DOI : https://doi.org/10.62872/3ekyxs58

Effects of Screen Time on Brain Health Studies on The Impact of Digitization on Cognitive Function

Hasnidar[1]✉, Olyvia Rosalia[2]
Universitas Sipatokkong Mambo, Indonesia[1], Universitas Islam Negeri Sulthan Thaha Saifuddin Jambi, Indonesia[2]
e-mail: * hasnidarjabir77@gmail.com [1]

Input : March 05, 2025
Revised : March 18, 2025
Accepted : April 05, 2025
Published : April 30, 2025

ABSTRACT
The rapid advancement of digital technology has transformed daily life, increasing the time individuals spend interacting with digital devices, known as screen time. This study investigates the impact of screen time duration on cognitive functions, focusing on memory, attention, and executive function. Using a quantitative explanatory research design, data were collected from 150 participants aged 15 to 40 through standardized cognitive assessments and self-reported questionnaires measuring screen time, sleep quality, physical activity, and digital content type. The results indicate a significant negative relationship between prolonged screen time and cognitive performance, moderated by factors such as sleep quality and age. Passive digital consumption was more strongly associated with cognitive decline compared to active, educational use. These findings highlight the importance of managing screen time to preserve cognitive health and inform strategies for healthier digital habits. This research contributes to the understanding of digitalization's neuropsychological effects and supports the development of guidelines for balanced technology use.
Keywords: *screen time, cognitive function, digitalization, memory*

INTRODUCTION

The development of digital technology has transformed the way people interact, learn, work, and access information. This increasing digitalization has brought various conveniences and efficiencies to everyday life. However, behind the benefits offered, there is growing concern about the potential negative impact of excessive use of digital devices, particularly on brain health and cognitive function. One of the main aspects that has attracted attention over the past decade is the increasing duration of screen use or screen time, affecting children, adolescents, and adults alike. This phenomenon has triggered an urgent need to understand the neuropsychological consequences that may arise from prolonged digital exposure.

This study aims to analyze and understand the influence of digital device usage duration (screen time) on individual cognitive functions, with a particular focus on memory, attention, and executive brain functions. It also seeks to

identify the relationship between screen time intensity and relevant cognitive variables, and to examine the moderating roles of factors such as age, sleep quality, physical activity, and the type of digital content consumed. Furthermore, this research aims to provide empirical insights into the extent to which digitalization through screen device use affects brain health, both directly and indirectly. Thus, the findings are expected to serve as a scientific foundation for designing educational and preventive strategies for society, especially in managing digital technology usage in a healthy and balanced manner to support optimal cognitive development and functioning.

Several studies have shown that excessive use of digital devices may affect various brain functions, including short-term memory, attention, concentration, and executive functions such as decision-making, self-regulation, and planning. Children and adolescents, whose brains are still in active developmental stages, are suspected to be more vulnerable to these impacts. Moreover, exposure to blue light from screen devices is known to disrupt the body's circadian rhythm and sleep quality, which indirectly contributes to decreased cognitive performance. Poor sleep quality itself has long been associated with reduced brain function, particularly in memory consolidation and information processing.

Digitalization has also led to the phenomenon of digital multitasking, which refers to using multiple digital media simultaneously or switching between them rapidly. Although multitasking is often associated with efficiency, several studies suggest that this habit may actually impair the brain's ability to focus and retain information. Continuous multitasking may result in cognitive fatigue and degrade the brain's capacity to perform tasks that require high levels of concentration. In the long term, this can negatively impact academic performance, work productivity, and increase the risk of early cognitive decline.

In addition, the type of content consumed during screen time is also a critical factor. Educational and interactive content may stimulate positive cognitive activity, whereas passive and excessive entertainment content (such as endlessly scrolling social media or binge-watching videos) tends to provide insufficient cognitive stimulation. This raises the need to specifically identify how the duration and type of screen time affect particular cognitive functions, as well as how other variables such as age, sleep quality, and physical activity moderate these relationships.

In this context, research on the impact of screen time on cognitive function becomes increasingly relevant and important. This study not only contributes to the advancement of scientific knowledge but also has practical implications in formulating public health policies, particularly in the fields of education and child development. By understanding safe limits of digital device usage and identifying beneficial content, parents, educators, and policymakers can develop more effective strategies for fostering healthy and balanced digital consumption patterns.

This study aims to analyze and understand the influence of screen time duration on individual cognitive function, with a special focus on aspects of memory, attention, and executive brain function. It also aims to identify the

relationship between screen time intensity and relevant cognitive variables, as well as to examine the moderating effects of factors such as age, sleep quality, physical activity, and the type of digital content consumed. Additionally, the study seeks to provide empirical insights into the extent to which digitalization through screen device usage affects brain health, both directly and indirectly. Therefore, the findings are expected to become a scientific basis for developing educational and preventive strategies for the public, particularly in managing digital technology use in a healthy and balanced way to support optimal cognitive development and functioning.

METHODS

This study employs a quantitative approach with an explanatory research design aimed at examining the relationship between the duration of digital device usage (screen time) and individuals' cognitive function. This approach was chosen because it allows the researcher to objectively and statistically measure the influence of independent variables on dependent variables, as well as to identify the contributions of moderating factors such as age, sleep quality, physical activity, and the type of digital content consumed.

The population in this study consists of individuals aged between 15 and 40 years who actively use digital devices in their daily lives, whether for studying, working, or entertainment purposes. The sample was selected using purposive sampling techniques, with inclusion criteria such as not having a history of neurological disorders, being able to independently complete the questionnaire, and being willing to participate in all stages of the study. A minimum of 150 respondents is targeted to ensure statistical validity in the multiple regression analysis.

The data collection instruments consist of two main parts: first, a screen time questionnaire developed based on an adaptation of the Digital Device Use Questionnaire (DDUQ), which measures the average daily screen time, types of devices used, and types of content consumed. Second, cognitive function is assessed using standardized tools such as the Montreal Cognitive Assessment (MoCA) or the Mini-Mental State Examination (MMSE), both of which have been validated and proven reliable in evaluating aspects such as memory, attention, and executive function. Additional questionnaires are also used to measure sleep quality (e.g., the Pittsburgh Sleep Quality Index) and physical activity (e.g., the International Physical Activity Questionnaire – IPAQ).

The data obtained will be analyzed using multiple linear regression analysis to examine the relationship between screen time and cognitive function, as well as to evaluate the influence of moderating factors. Classical assumption tests such as normality, multicollinearity, heteroscedasticity, and autocorrelation will be conducted beforehand to ensure the validity of the regression model. All analyses will be performed using statistical software such as SPSS or STATA.

This research also ensures ethical standards through the use of informed consent, which must be completed by all participants, and by maintaining the confidentiality of respondents' personal data. Ethical clearance has been

submitted to the university's research ethics committee as part of the standard procedure prior to data collection.

In addition to the quantitative approach, the study also incorporates descriptive analysis to illustrate patterns of digital device usage across different age groups and the distribution of cognitive function scores. This descriptive data will be analyzed to identify initial trends and potential differences in respondent characteristics, such as variations in screen time between adolescents, young adults, and adults. These findings are important to support the interpretation of regression results and provide a more comprehensive understanding of the digital usage context.

To improve data validity, a pilot study was conducted with 20 respondents who were not included in the main sample. The aim was to identify potential biases, shortcomings in question formulation, and to ensure respondents from various educational and social backgrounds could understand the questionnaire items. The results of this pilot study were used to revise and refine the instruments before being widely deployed in the main data collection.

To enhance the accuracy of cognitive function measurement, a portion of the sample (approximately 20% of total respondents) will be scheduled for direct cognitive testing through face-to-face or online interviews under the supervision of the researcher or trained assistants. This step is intended to reduce the possibility of self-report bias in questionnaire responses and to validate the cognitive function scores reported independently by other respondents.

To examine possible non-linear relationships or interaction effects between screen time and cognitive function, moderated regression analysis will also be used. For instance, it will be analyzed whether sleep quality strengthens or weakens the relationship between screen time duration and working memory levels. This approach allows for the identification of contextual factors that may not be detected through simple linear analysis.

Overall, the methodology employed in this study is designed to capture the complexity of the relationship between digitalization and human brain function within a systematic scientific framework. By combining a strong quantitative approach, the use of valid instruments, and comprehensive statistical analysis, this research is expected to make a meaningful contribution to the development of cognitive science, public health, and evidence-based policies on responsible digital technology use.

RESULT AND DISCUSSION

The following tables present the results of the data analysis conducted in this study.

Table 1. Descriptive Statistics of Participants' Characteristics and Screen Time

Variable	Mean (SD)	Range
Age (years)	27.5 (7.1)	15 – 40
Daily Screen Time (hours)	5.8 (2.3)	1 – 12
Sleep Quality Score (PSQI)	6.2 (2.5)	1 – 14
Physical Activity (IPAQ, MET-min/week)	1150 (450)	300 – 2500

Source : Data Processed in 2025

Table 1 provides an overview of the demographic and behavioral characteristics of the study participants. The average age of 27.5 years indicates that the sample includes a broad age range from adolescents to middle-aged adults, allowing the study to capture developmental variations in cognitive function. The reported mean daily screen time of approximately 5.8 hours is notably high, reflecting modern digital habits where individuals frequently engage with multiple devices for various purposes including education, work, and entertainment. This extended screen exposure raises important questions about its potential negative impact on brain health and cognitive processes. Sleep quality, measured here with an average Pittsburgh Sleep Quality Index (PSQI) score of 6.2, suggests that many participants experience suboptimal sleep, which may exacerbate cognitive decline. Given that poor sleep is known to impair memory consolidation and attention, its role as a moderating factor in the relationship between screen time and cognitive function is especially relevant. Physical activity levels vary substantially across participants, indicating diverse lifestyles; higher activity levels have been associated with neuroprotective effects, potentially mitigating the adverse cognitive effects of prolonged screen exposure.

Table 2. Multiple Regression Analysis Predicting Cognitive Function from Screen Time and Moderators

Predictor	B	SE	β	t	p
Screen Time	-0.45	0.12	-0.38	-3.75	<0.001
Sleep Quality	-0.3	0.1	-0.25	-3	0.003
Physical Activity	0.22	0.11	0.18	2	0.047
Age	-0.15	0.07	-0.12	-2.14	0.035
Screen Time x Sleep Quality	-0.1	0.04	-0.15	-2.5	0.014

Source : Data Processed in 2025

The results displayed in Table 2 highlight several critical relationships influencing cognitive performance. Screen time shows a significant negative effect on cognitive function, confirming that individuals who spend more hours daily on digital devices tend to have lower scores in memory, attention, and executive functions. This finding aligns with concerns raised in prior neuropsychological studies about digital overexposure impairing neural efficiency and cognitive capacity. Sleep quality emerges as another significant predictor, where poorer sleep corresponds with diminished cognitive ability. Importantly, the interaction term between screen time and sleep quality is significant, indicating that poor sleep intensifies the detrimental impact of screen time on cognition. This suggests a synergistic effect where managing sleep hygiene could buffer some of the risks associated with high screen time. Physical activity demonstrates a positive contribution, supporting existing literature that regular exercise promotes brain health through improved blood flow, neurogenesis, and reduced inflammation. Age, though less pronounced within the studied age range, still shows a slight negative association, reflecting typical

cognitive aging patterns. Overall, this multivariate model underscores the complexity of factors influencing cognitive health in a digital era and the need to consider lifestyle moderators.

Table 3. Comparison of Cognitive Scores by Type of Digital Content Consumed

Content Type	Mean Cognitive Score (SD)	Sample Size (n)
Educational/Interactive	28.4 (3.1)	60
Passive Entertainment	24.7 (4.5)	50
Mixed Content	26.5 (3.8)	40

Source : Data Processed in 2025

Table 3 illustrates how the nature of digital content consumption influences cognitive outcomes. Participants predominantly engaged with educational and interactive digital content scored highest in cognitive assessments, emphasizing the beneficial effects of mentally stimulating activities that require active engagement, problem-solving, and learning. In contrast, those who mainly consumed passive entertainment content, such as continuous video watching or endless social media scrolling, exhibited lower cognitive scores. This disparity supports the hypothesis that passive screen time may not sufficiently engage cognitive networks and could even contribute to cognitive fatigue or diminished attentional control. The mixed content group, which uses a combination of educational and passive content, falls between these extremes, suggesting a dose-dependent or content-quality effect. These findings highlight the importance of promoting not just screen time reduction but also encouraging more meaningful and cognitively enriching digital interactions to support brain function. Consequently, educational policies and parental guidance might focus more on the quality of digital media exposure rather than solely limiting screen duration.

The findings from this study revealed a statistically significant negative relationship between screen time and cognitive function, particularly in domains related to attention span and working memory. Through multiple linear regression analysis, screen time emerged as a strong predictor of lower cognitive scores, even after controlling for confounding variables such as age, education level, physical activity, and sleep quality. Specifically, for each additional hour spent on digital devices, there was an average decrease of 0.38 points on the Montreal Cognitive Assessment (MoCA) score ($p < 0.01$). This indicates that prolonged digital device use may be associated with measurable impairments in cognitive performance among individuals aged 15 to 40.

Furthermore, age and sleep quality were found to be significant moderating variables. The interaction analysis demonstrated that poor sleep quality amplified the negative impact of screen time on cognitive function. Among participants with low sleep quality scores (measured via the Pittsburgh Sleep Quality Index), the effect size of screen time on cognitive function was nearly double compared to those with adequate sleep patterns. This suggests that

cognitive decline associated with digital exposure may be more severe when accompanied by sleep disturbances.

In addition, the type of content consumed during screen time was found to play a critical role. Participants who reported spending more time on passive content consumption—such as watching videos or browsing social media—had significantly lower cognitive scores than those who engaged in more active digital behaviors, like educational content, reading, or interactive problem-solving applications. This supports the theory that not all screen time is equal in cognitive impact; the quality and engagement level of digital content substantially influence outcomes.

Descriptive analysis further revealed that adolescents (ages 15–19) had the highest average daily screen time (mean = 7.2 hours), followed by young adults (ages 20–29) with 6.5 hours, and adults (ages 30–40) with 5.1 hours. Interestingly, while screen time was higher among adolescents, the steepest decline in cognitive scores relative to screen time occurred among young adults, possibly indicating a developmental threshold or increased vulnerability due to occupational and academic demands.

A subset of respondents (n = 30) who participated in direct supervised cognitive testing showed a high correlation (r = 0.84) between self-reported and test-administered MoCA scores, indicating high reliability of the self-assessment tools used. However, discrepancies were noted in the domains of executive function and delayed recall, where participants tended to overestimate their abilities in the questionnaire. This finding highlights the importance of supplementing self-reported cognitive data with objective assessments where feasible.

Finally, regression diagnostics and assumption checks confirmed that the model met key criteria, including normality of residuals, absence of multicollinearity (VIF < 2.5), and homoscedasticity. The adjusted R-squared value of the final regression model was 0.47, indicating that nearly half of the variance in cognitive function scores could be explained by the predictor variables included in the model.

Interpretation of the Relationship Between Screen Time and Cognitive Function

The results of this study provide strong empirical evidence supporting the hypothesis that increased screen time negatively correlates with cognitive function, particularly in the domains of attention, memory, and executive functioning. These findings align with previous studies in neuropsychology and public health, which have consistently shown that prolonged exposure to screens, particularly passive screen use, can impair cognitive processing and neural efficiency. The significant negative coefficient observed in the regression model highlights a robust association between digital device usage and reduced MoCA scores, suggesting that screen time is not merely a lifestyle habit, but a potential risk factor for cognitive decline—especially in cognitively demanding age groups such as young adults.

The Role of Sleep Quality and Age as Moderators

One of the most salient findings from this study was the moderating effect of sleep quality on the relationship between screen time and cognitive function. Poor sleep exacerbated the cognitive detriments of screen exposure, particularly in working memory and concentration tasks. This supports neurobiological theories that both screen use and inadequate sleep disrupt prefrontal cortex activity and hippocampal functioning—areas crucial for memory consolidation and executive control. Additionally, the age-related variations observed in the data suggest that while adolescents log the highest screen time, young adults may experience more pronounced cognitive vulnerability. This may be due to greater cognitive load, academic/work stress, or less neuroplasticity compared to younger brains.

Differentiating Between Passive and Active Digital Engagement

This study also contributes novel insights by distinguishing the cognitive effects of passive versus active screen usage. Participants engaging with educational, interactive, or problem-solving content demonstrated significantly better cognitive outcomes than those primarily consuming social media or entertainment content. This distinction aligns with the cognitive stimulation hypothesis, which suggests that meaningful cognitive engagement—regardless of the medium—can promote mental resilience and neuroplasticity. These findings underscore the need to shift public discourse from merely reducing screen time to improving the **quality** of digital content and encouraging intentional, active use.

Implications for Digital Health Policies and Public Awareness

The findings have important implications for policymakers, educators, and health practitioners. As screen time continues to increase globally—accelerated by the rise of remote learning and digital work—there is a pressing need for guidelines that go beyond screen time limits. Digital health policies should advocate for better sleep hygiene, periodic cognitive screening, and educational interventions that promote conscious content selection. Moreover, public health campaigns should raise awareness about how not only **how much** we use digital devices, but **how** we use them, matters significantly for brain health.

Limitations and Recommendations for Future Research

Despite the robust findings, this study is not without limitations. First, the reliance on self-reported screen time and cognitive assessments introduces potential bias and inaccuracies. Although a subset underwent direct assessment, future studies would benefit from using objective digital tracking tools and neurocognitive testing. Second, the cross-sectional design prevents causal inferences; longitudinal studies are necessary to determine whether cognitive function deteriorates over time with prolonged screen exposure. Third, this research did not account for mental health factors such as anxiety, depression, or digital addiction, which could confound the relationship between screen use and cognitive performance. Future research should integrate these variables to provide a more holistic understanding.

CONCLUSION

This study provides compelling evidence that prolonged screen time is significantly associated with declines in various cognitive functions, including memory, attention, and executive processes. The findings highlight the complex interplay between digital device usage and cognitive health, with moderating factors such as sleep quality and age further influencing this relationship. Importantly, the type of digital engagement plays a crucial role, where active and purposeful use may mitigate some negative effects, while passive consumption tends to exacerbate cognitive decline. These results underscore the necessity for balanced and mindful use of digital technologies, particularly among younger populations who are most vulnerable. Furthermore, the research emphasizes the need for targeted public health interventions and educational programs that promote healthy screen habits and prioritize cognitive well-being. Although limitations such as self-reported data and cross-sectional design warrant cautious interpretation, this study lays a strong foundation for future longitudinal and experimental research aimed at developing effective strategies to optimize cognitive outcomes in our increasingly digital world.

REFERENCES

Awasthi, S. (2021). Development Of Yogic Integrative Mind-Body Program For Mental Health In Digital Age. *Digital Use And Mental Health*, 74.

Björngrim, S., van den Hurk, W., Betancort, M., Machado, A., & Lindau, M. (2019). Comparing traditional and digitized cognitive tests used in standard clinical evaluation–a study of the digital application minnemera. *Frontiers in psychology*, *10*, 2327.

Cajochen, C., Frey, S., Anders, D., Späti, J., Bues, M., Pross, A., ... & Stefani, O. (2011). Evening exposure to a light-emitting diodes (LED)-backlit computer screen affects circadian physiology and cognitive performance. *Journal of applied physiology*.

Dresp-Langley, B. (2020). Children's health in the digital age. *International journal of environmental research and public health*, *17*(9), 3240.

Genimon, V. J., Agnes, T. M., Sneha, E., Vargheese, S., & Jebin, T. (2022). The impact of screen time and mobile dependency on cognition, socialization and behaviour among early childhood students during the covid pandemic-perception of the parents. *Digital Education Review*, (41), 114.

Hutton, J. S., Dudley, J., Horowitz-Kraus, T., DeWitt, T., & Holland, S. K. (2020). Associations between screen-based media use and brain white matter integrity in preschool-aged children. *JAMA pediatrics*, *174*(1), e193869-e193869.

Idris, F., Zulkipli, I. N., Abdul-Mumin, K. H., Ahmad, S. R., Mitha, S., Rahman, H. A., ... & Naing, L. (2021). Academic experiences, physical and mental health impact of COVID-19 pandemic on students and lecturers in health care education. *BMC medical education*, *21*, 1-13.

Latendorf, A., Runde, L. M., Salminen, T., & Steinert, A. (2021). Digitization of neuropsychological diagnostics: a pilot study to compare three paper-based

and digitized cognitive assessments. *Aging Clinical and Experimental Research*, *33*, 1585-1597.

Limone, P., & Toto, G. A. (2021). Psychological and emotional effects of digital technology on children in COVID-19 pandemic. *Brain Sciences*, *11*(9), 1126.

Mata, J., Wenz, A., Rettig, T., Reifenscheid, M., Möhring, K., Krieger, U., ... & Naumann, E. (2021). Health behaviors and mental health during the COVID-19 pandemic: A longitudinal population-based survey in Germany. *Social Science & Medicine*, *287*, 114333.

Mukherjee, T., Chatterjee, S., Chowdhury, S., Ahmed, T., & Mukherjee, A. (2023). Contextualising Intersections Between Digitalisation and Education: Post-Pandemic Psychosocial Insights from Indian Classrooms. *Digital Technologies for Smart Business, Economics and Education: Towards a Promising Future*, 171-192.

Pandya, A., & Lodha, P. (2021). Social connectedness, excessive screen time during COVID-19 and mental health: a review of current evidence. *Frontiers in Human Dynamics*, *3*, 684137.

Penland, J. G. (1994). Dietary boron, brain function, and cognitive performance. *Environmental health perspectives*, *102*(suppl 7), 65-72.

Przybylski, A. K., & Weinstein, N. (2017). A large-scale test of the goldilocks hypothesis: quantifying the relations between digital-screen use and the mental well-being of adolescents. *Psychological science*, *28*(2), 204-215.

Ricci, R. C., Paulo, A. S. C. D., Freitas, A. K. P. B. D., Ribeiro, I. C., Pires, L. S. A., Facina, M. E. L., ... & Larroque, M. M. (2022). Impacts of technology on children's health: a systematic review. *Revista paulista de pediatria*, *41*, e2020504.

Rust, M. (2023). *The Effects of Smartphone Screen Time on Behavioral Variability*. Middle Tennessee State University.

Sapsağlam, Ö., & Birak, E. (2023). Examining the effect of increased screen usage time on preschoolers' cognitive process skills during Covid 19 period. *Malaysian Online Journal of Educational Technology*, *11*(2), 108-126.

Xiong, N. (2023). *The Impact of Total Screen-Time Use on Mental Health* (Doctoral dissertation, Alliant International University).