Screen Time and Learning Disabilities in Preschool Children

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Original Article

ABSTRACT

Background: Since the emergence of COVID-19, children have been using screens more frequently. Increased screen time has been linked to decreased brain white matter networks' microstructural integrity, which supports language and literacy abilities.

Objectives: To evaluate the association between excessive screen time and learning disabilities among preschool children.

Patients and Methods: This cross-sectional study was conducted on 80 children, aged 4.5-6.5 years, who were attending routine preschool assessment at the phoniatric clinic of the Hearing and Speech Institute, Cairo, Egypt, from October 2022 to April 2023. Children were classified according to screen time into <2h/day, 2-4 h/day, and >4h/day. The learning disabilities were assessed in all children using standardized tests, such as the Stanford-Binet Intelligence Scales and emergent literacy test.

Results: Overuse of screens was linked to poorer visual processing, auditory processing, and auditory memory functions but did not influence visual memory. Increased screen usage was also linked to lower overall working memory and emergent literacy scores. The time spent using screens since birth was substantially inversely related to memory development.

Conclusion: Prolonged screen time was significantly associated with learning disabilities by negatively affecting auditory and visual processing, working memory, and emergent literacy skills among preschool children.

Key Words: Learning disabilities, preschoolers, screen-time.

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INTRODUCTION

"learning disabilities" (LDs) are a broad category of conditions marked by impairment and challenges in developing and using speaking, writing, reading, and math skills. According to recent studies conducted in Egypt, 16.5% of preschoolers have LDs[1]. During preschool, children engage in active play and socialization with their surroundings, fostering their social and cognitive abilities[2]. Interaction with adults is the primary means of acquiring various language and learning domains throughout this crucial time of language acquisition and literacy development[3].

There has been an unheard-of rise in screen time (ST) with the emergence of COVID-19[4], and it's becoming a regular feature of kids' lives, especially those in preschool. ST entails utilizing a variety of gadgets, including computers, gaming consoles, mobile phones, and televisions[5]. The American Academy of Pediatrics (AAP) advises preschoolers to use screens for no more than an hour a day[6].

Therefore, it has been shown that excessive ST (more than 2-3 hours) is linked to decreased developmental activities like schoolwork and active play, which exposes kids to language, literacy, and communication skills-all essential for academic success[7]. Additionally, it may significantly impact children's developing brains, which could affect learning and memory, emotional control, cognitive and motor development, and general health[6]. Using functional brain MRI, recent research has demonstrated a correlation between increased screen use and decreased microstructural integrity of brain white matter circuits that support language and reading skills[8].

While non-educational screen content may impede these areas, certain interactive and educational information has been demonstrated to benefit language and cognitive development. While studies have shown that abilities gained by electronic media are frequently limited compared to those acquired in real-life circumstances, electronic media can be employed for instructional reasons[9].

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Considering these complications, we aimed to investigate ST's benefits and drawbacks for preschoolers. Research on the precise association between screen usage and learning outcomes in preschool-aged children is lacking. Few studies have looked at the effects of prolonged screen exposure on early childhood cognitive skills and academic performance; most prior research has concentrated on school-aged children and adolescents. Other studies have examined the impact of screens on language development in early childhood (less than three years).

More precisely, since children's cognitive development can differ depending on their cultural surroundings, such examination needs to be done in Egypt. By minimizing possible hazards to learning during critical neurodevelopmental windows in the preschool years, this research may help optimize benefits.

The study aimed to assess the relationship between learning difficulties in preschool-aged children (ages 4.5–6.5 years) and increased screen use (> 2 hours per day).

PATIENTS AND METHODS:

A cross-sectional study was carried out between October 2022 and April 2023 in the Phoniatric department of the Hearing and Speech Institute, Giza, Egypt. 80 preschoolers, ages 4.5 to 6.5 years, who regularly attended the phoniatric clinic for preschool assessment were included in this study. The children included had an average intelligence quotient (IQ) of 90 or higher in the Stanford-Binet test, Fourth Edition (SB4)[10], they were native Arabic speakers, and their average language age (as determined by the modified PLS4)[11] was in line with their chronological age and normal hearing (20-30 db and 2-4 k/hz).

The study excluded any children with a history of mental, neurological, or metabolic abnormalities; it also did not include any children with visual or auditory dysfunctions. Written informed consent was signed by all parents whose children were part of the study.

All procedures were approved by the General Organization of Teaching Hospitals and Institutes (GOTHI) Research Ethics Committee on October 5, 2022, under approval number IHS00042. The procedures followed the 2013 Helsinki Declaration and the ethical standards of the responsible committee on human experimentation.

2.1 History taking

A comprehensive questionnaire regarding the child's name, birth date, gender, number of siblings, language skills, learning capabilities, attention span, behavior, and developmental history was given to parents to fill out. Furthermore, parents were questioned regarding their child's overall daily screen usage (measured in hours), which included time spent on TV, smartphones, and tablets. The inquiry was formulated as follows: How much time did your child spend in front of screens daily? The kids' screen usage was divided into three groups (<2 hrs, 2-4 hrs, > 4 hrs). The length of screen exposure in years was another question posed to the parents by "since birth". The query was formulated as follows: How long has the child interacted with screens?

2.2 Assessment of LDs

2.2.1 Assessment of "auditory memory" (AM), "auditory processing" (AP), "visual memory" (VM), and "visual processing" (VP) was conducted using the Stanford-Binet test, Fourth Edition (SB4). AM is remembering and storing auditory information, including numbers, sounds, melodies, and spoken words[12]. AP is the brain's capacity to decipher and comprehend auditory information, including speech, ambient noises, and music[13]. VM is the cognitive capacity to remember, recollect, and mentally reconstruct visual information from the past[14]. VP is the ability to register, decode, and comprehend visual stimuli. It needs an intricate cognitive and neurological process to decipher and make sense of visual information obtained from the environment[15].

2.2.2 "Working memory" (WM) is a vital cognitive component for many facets of early learning; it enables kids to store and process information in their brains temporarily; it contains three components: central executive function, phonological loop, and visuospatial sketchpad[16]. WM was evaluated using the Stanford-Binet test, Fifth Edition (SB5)[17].

AM, AP, VM, and VP of the (SB4) and WM of the (SB5), scores are categorized into the following classifications: 110-119 - High Average, 90-109 – Average, 80-89 - Low Average, 70-79 – Borderline, 60-69- mild and below 60 moderates (the most affected).

2.2.3 "Emergent literacy skills" related to the included age group were evaluated using the test battery proposed by Afsah[18], a valid and reliable screening tool for preschoolers to identify children at risk of subsequent reading problems by assessing both phonological processing and emergent literacy skills. Phonological processing is a prerequisite for developing emergent literacy skills. A composite score of 59 is the maximum possible result from the emergent literacy and phonological processing tests. The median values of the entire battery were computed; a child's score is below average if scores are less than the median. Nonetheless, average performance is indicated if scores are equal or above the median.

2.3 Statistical Analysis:

Data were collected, revised, coded, and entered into the Statistical Package for Social Science (IBM SPSS) version 27. The quantitative data were presented as mean, standard deviations, and ranges when parametric, while non-parametric data was represented as median and inter-quartile range (IQR). Also, qualitative variables were presented as numbers and percentages.

The comparison between groups regarding qualitative data was done using the Chi-square and/or Fisher exact tests when the expected count in any cell was less than 5.

The comparison between more than two groups regarding quantitative data with parametric distribution was done using the One Way ANOVA test followed by post hoc analysis using the LSD test. In comparison, non-parametric distribution was done using the Kruskall-Wallis test, and post hoc analysis was done using the Mann-Whitney test.

Spearman correlation coefficients were used to assess the correlation between two quantitative parameters in the same group. The confidence interval was 95%, and the accepted error margin was 5%. So, *P-values < 0.05* were considered significant, *P-values<0.01* were considered highly significant, and *P-values >0.05* were considered non-significant.

RESULTS:

Demographic and screen-use data were gathered and analyzed to ascertain the relationship between ST and LDs among the enrolled children. We conducted a cross-sectional study on 80 children between the ages of 4.5 and 6.5 years.

The mean ± SD age of the children was 5.8 ± 0.52 years, with 30 (37.5%) females and 50 (62.5%) males. The enrolled children were divided into three groups based on the ST: 27 (33.8%) with ST <2 hours, 29 (36.3%) with ST between 2 and 4 hours, and 24 (30.0%) with ST >4 hours. The mean ± SD of all children's IQ was 97.32 ± 6.15, and the mean ± SD average of duration of children's interaction with screens (years) was 4.15 ± 0.63 years.

Table 1: Auditory processing, auditory memory, visual processing, visual memory, working memory, and "phonological processing and emergent literacy score" among the studied patients

			Total no. = 80
Stanford-Binet 4 domains	AP	Median (IQR)	78 (73.5 – 81)
		Range	65 – 95
	AM	Median (IQR)	78 (73.5 – 81)
		Range	64 – 95
	VP	Median (IQR)	86 (81.5 – 90)
		Range	74 – 99
	VM	Median (IQR)	89 (82 – 92)
		Range	72 – 95
WM		Median (IQR)	88 (82 – 91.5)
		Range	72 – 95
Phonological processing and emergent literacy score		Median (IQR)	41 (36.5 – 44)
		Range	31 – 56

According to (Table 1), The median (interquartile range IQR) scores for auditory processing (AP), auditory memory (AM), visual processing (VP), visual memory (VM), working memory (WM), and "phonological processing and emergent literacy score" as follows: 78 (73.5 – 81) below average for both auditory (AP) processing and auditory memory (AM), 86 (81.5 – 90) average for visual processing (VP), 89 (82 – 92) average for visual memory (VM), 88 (82 – 91.5) average for working memory (WM), and 41 (36.5 – 44) average for "phonological processing and emergent literacy score."

Table 2: Relation of screen time with demographic data and characteristics of the studied children

		ST < 2 hrs	ST (2 – 4) hrs	ST > 4 hrs	Test value	*P-value*	Sig.
		No. = 27	No. = 29	No. = 24			
Age (years)	Mean ± SD	5.81 ± 0.56	5.81 ± 0.46	5.78 ± 0.55	0.024•	0.976	NS
	Range	4.67 – 6.5	4.67 – 6.5	4.83 – 6.5			
Sex	Female	10 (37.0%)	12 (41.4%)	8 (33.3%)	0.366*	0.833	NS
	Male	17 (63.0%)	17 (58.6%)	16 (66.7%)			
IQ	Mean ± SD	96.41 ± 6.01	98.07 ± 6.87	97.46 ± 5.48	0.511•	0.602	NS
	Range	89 – 113	88 – 114	90 – 110			
Duration of children's interaction with screens (years)	Mean ± SD	3.94 ± 0.7	4.28 ± 0.39	4.23 ± 0.74	2.289•	0.108	NS
	Range	2 – 5	3.5 – 5	2.5 – 5			

P-value > 0.05: Non-significant; *P-value < 0.05*: Significant; *P-value < 0.01*: Highly significant
*: Chi-square test; •: One Way ANOVA test

Table 2 shows the relationship between screen time and the demographic information and features of the studied children, including age, sex, IQ, and the duration of children's interaction with screens in years. No significant differences between the groups (>2 hrs, 2-4 hrs, and >4 hrs) were observed.

Analyzing the relationship between screen time and age is valuable as it may provide insights into how technology exposure varies across developmental stages. Younger children may have distinct responses or susceptibilities to screen time compared to older counterparts. Similarly, examining the correlation between screen time and the duration of interaction with screens over the years is crucial for identifying potential cumulative effects of screen exposure.

Table 3: Relation between screen time and auditory processing, auditory memory, visual processing, visual memory, working memory, and "phonological processing and emergent literacy score"

			Screen time < 2 hrs	Screen time (2 – 4) hrs	Screen time > 4 hrs	Test value	*P-value*	Sig.
			No. = 27	No. = 29	No. = 24			
Stanford-Binet 4	AP	Median (IQR)	82(79 – 90)	79(76 – 83)	71.5(69 – 75)	36.110≠	0.000	HS
		Range	74 – 95	69 – 89	65 – 80			
	AM	Median (IQR)	83(78 – 90)	79(76 – 80)	70(69 – 74)	33.486≠	0.000	HS
		Range	64 – 95	74 – 84	65 – 86			
	VP	Median (IQR)	88(82 – 99)	86(85 – 88)	80.5(77 – 87.5)	8.321≠	0.016	S
		Range	75 – 99	78 – 99	74 – 99			
	VM	Median (IQR)	89(80 – 92)	88(85 – 90)	89(81 – 92)	0.558≠	0.757	NS
		Range	72 – 95	78 – 95	74 – 95			
WM		Median (IQR)	90 (84 – 92)	86 (83 – 90)	84 (79.5 – 89)	8.550≠	0.014	S
		Range	72 – 95	79 – 95	74 – 95			
Phonological processing and emergent literacy score		Median (IQR)	44 (39 – 48)	41 (36 – 43)	38.5 (35.5 – 41)	6.953≠	0.031	S
		Range	32 – 54	31 – 56	33 – 47			

Post Hoc analysis

	P1	P2	P3
Auditory processing	0.033	0.000	0.000
Auditory memory	0.001	0.000	0.000
Visual processing	0.395	0.023	0.009
Total WM	0.089	0.077	0.008
Phonological processing and emergent literacy score	0.062	0.370	0.013

hrs- hours; IQR- Interquartile range; No - Number.
P-value < 0.05: Significant; *P-value < 0.01*: Highly significant ≠: Kruskal-Wallis test
P1: ST < 2 hrs Vs. ST (2 – 4) hrs; P2: screen time (2 – 4) hrs Vs. ST >4 hrs; P3: screen time < 2 hrs Vs. ST >4 hrs

Table 3 outlines the connection between children's test results and screen time, covering aspects such as auditory memory (AM), visual perception (VP), visual memory (VM), working memory (WM), and Phonological processing and emergent literacy score. Notable differences were found in auditory memory (AM) and auditory processing (AP) scores (*P-value = 0.00*), as well as significant distinctions in visual processing (VP) (*P-value = 0.016*), while visual memory (VM) showed no significant difference (*P-value = 0.757*). The results revealed significant variations in children's working memory (WM) and "phonological processing and emergent literacy score" performance among the three groups (*P-values* of *0.014* and *0.031*). Post hoc tests highlighted substantial differences in children's achievement across all tests, specifically, in the comparisons between screen time categories, higher screen time (> 4 hrs) correlated with notable changes in various parameters except for visual memory (VM).

Table 4: Correlation of Duration of children's interaction with screens (years) with scores of auditory processing, auditory memory, visual processing, visual memory, working memory, and "phonological processing and emergent literacy score" among the studied children

	Duration of children's interaction with screens (years)	
	r	*P-value*
AP	-0.328**	0.003
AM	-0.285*	0.010
VP	-0.348**	0.002
VM	-0.037	0.748
WM	-0.324**	0.003
Phonological processing and emergent literacy	-0.324**	0.003

P-value > 0.05: Non-significant; *P-value < 0.05*: Significant; *P-value < 0.01*: Highly significant
Spearman correlation coefficient

Table 4 Concerning auditory processing (AP), auditory memory (AM), visual processing (VP), working memory (WM), and "phonological processing and emergent literacy score," there was a statistically significant negative correlation observed with the duration of screen use in years. However, visual memory (VM) displayed a correlation that did not reach statistical significance.

DISCUSSION

Since the COVID-19 pandemic, 98% of children live with an internet-connected device and spend an average of more than two hours a day on screens for educational or recreational purposes[19]. This time exceeds the suggested (AAP) guideline, which states that children should not spend more than one hour daily[6]. Although some researchers reported some known advantages to engaging in ST, excessive screen time has also been linked to adverse physical, behavioral, and cognitive effects. It may even impede learning opportunities and academic performance[20].

One in four children exhibits delays and deficiencies in language, communication, motor abilities, and socioemotional health when they enter school. As a result, many children do not achieve academic success[21]. Without intervention, developmental gaps often grow rather than close over time, burdening the educational system with higher public and governmental spending on special education and remediation[22].

Unfortunately, there are very few studies-mostly questionnaires-on the relationship between screen use and learning difficulties. So, this study aimed to enhance the assessment of preschoolers' learning abilities by employing standardized and evidence-based practices. The focus was on establishing valid and reliable measures to objectively evaluate the impact of ST on various aspects of learning.

We conducted a cross-sectional study on 80 children between the ages of 4.5 and 6.5 years. The enrolled children were divided into <2 hours., 2 to 4 hrs., and >4 hrs., based on their total daily ST. Excessive ST did not correlate with VM but was linked to low AM, AP, VP, WM, and emergent literacy scores, and they were more affected in those who spent more time on a screen.

Intact AM and VM predict subsequent literacy and reading fluency and are crucial for academic success. Any problem with AM or VM may reduce the amount of information that can be recalled, making it harder to comprehend lengthy written or spoken explanations[23]. It was crucial to investigate how ST affected them both.

In this study, AM significantly decreased in participants with ST for more than two hours daily. At the same time, VM showed non-significant change, indicating that AM was affected earlier and experienced more incredible difficulty with elevated ST.

These findings could be explained by Bigelow and Poremba[24], who pointed out that human memory capacity for acoustic information is somewhat limited and that recognition accuracy for auditory stimuli is lower than that for visual stimuli. These findings precisely align with those of Mayer[25], who postulated that children who spend more time using technology than non-technological activities would have decreased AM and increased or unchanged VM. Contrary to our findings, Lillard and Peterson[26] and Stevens *et al*.[27] examined the impact of screen viewing on preschoolers' visual-spatial abilities and found that increased screen exposure was linked to worse VM performance.

Additionally, Chonchaiya *et al*.[28] and Fuentes *et al*.[29] revealed a connection between deficiencies in AM and high daily ST. Nevertheless, Hinkley *et al*.[30] and Boets *et al*.[31] investigated the relation between preschoolers' AM and found no evidence of a significant effect from ST on AM.

For learning, AP and VP are essential building blocks. For children to develop phonemic awareness, they must be able to hear and manipulate the unique sounds that makeup words[32]. Additionally, VP is important to identify visually identical letters, discern letter forms, and retain word order. Prolonged ST may cause problems with information processing speed rather than perceptual processes[33].

According to this study, children with ST (>2 hours per day) performed far worse on AP and VP tests. The combination of impairments may adversely affect early literacy skills and reading ability. Similarly, Sherman *et al*.[34], Hubert-Wallander *et al*.[35], and Tzavella *et al*.[36], reported that long-term ST has been shown to impair VP skills by decreasing sustained visual focus and concentration and making it harder to distinguish shapes and symbols.

Additionally, studies by Tomopoulos *et al*.[37] and Hubert-Wallander *et al*.[35] demonstrated how extended ST impairs AP by reducing phonological and speech perception skills and making it harder to discern foreground and background sounds. Eissa *et al*.[38] showed how excessive video games and cell phone usage impair central auditory processing abilities, which can impair attention span and memory.

Conversely, Kuhl *et al*.[39] investigated the impact of training with language-related videos highlighting AP and discovered that this intervention enhanced the child's capacity to distinguish speech sounds. Cardoso-Leite *et al*.[40] trained preschoolers' attention through a computer-based video game, and they improved their performance on AP and VP-related activities.

Evaluation of the impact of screens on WM has been required since childhood, which is thought to be a critical period for WM development. WM limitations can limit a preschooler's capacity to learn. Still, well-developed working memory (WM) and its components (phonological memory, visuospatial scratchpad, and executive function) have been linked to improved performance on tasks like following directions, understanding stories, solving math problems, and acquiring early literacy skills[41].

According to this study, children with ST (>2 hours per day) performed far worse on WM. Our results aligned with Piquard-Kipffer *et al*.[42], who discovered that preschoolers' lower phonological WM performance was associated with more than two hours of ST per day. Additionally, Alloway *et al*.[43] examined how screen exposure affected toddlers' executive function, including WM, and found that watching more ST was linked to worse WM performance. Longer ST has been linked to younger children's unsatisfactory performance on visuospatial WM and spatial reasoning tasks, according to Skiada *et al*.[44]; they explained that viewing fast-paced television decreases opportunities for visualizing and manipulating spatial information.

In contrast, a study by Cardoso-Leite *et al*.[40] trained preschoolers' attention and WM with a computer-based video game, and they showed improved performance on WM-related tasks.

In this study, we employed a test battery to identify preschoolers at risk of reading difficulties. The test measured both phonological processing and emergent literacy skills. Children with weak emergent literacy skills are at risk of later reading problems. Aside from the effects of socioeconomic status and IQ, the National Early Literacy Panel[45] identified some emerging literacy skills, such as phonological awareness, alphabet knowledge, oral language, and print awareness, that consistently predicted reading success.

According to our findings, children who spent >4hrs a day on screen-based media underperformed children who didn't, which is comparable to the findings of Žarić *et al*.[46], who looked at how screen-based media affected the reading skills development of preschoolers who might have dyslexia. They found that increased ST was associated with poorer reading abilities.

Pugh *et al*.[47] examined the connection between preschoolers at risk for dyslexia and computer-based reading programs. They discovered that specific computer programs had only modestly beneficial word and letter identification benefits, indicating a negligible effect on dyslexia. Horvath et a.[48] investigated how tablet-based therapies affected preschoolers' early literacy abilities, particularly reading difficulties. After engaging in tablet activities, they reported significant improvements in letter, word, and sound identification, indicating a beneficial effect.

Preschoolers are using screens more frequently, which has prompted questions about how this affects their brain development and capacity for learning. So, the association between young children's brain structure and function and ST has been investigated using fMRI.

According to fMRI study[49], there is a correlation between children's ST between the ages of 3 and 5 and a decrease in the volume of grey matter in brain regions related to language and language acquisition. Lower volumes or density of grey matter are generally correlated with decreased cognitive performance and abilities.

According to a study by Hutton *et al*.[50], children between the ages of 3 and 5 years exposed to screen media had less intact white matter in their left corona radiata. White matter fibers are essential for cognitive processes like attention and WM since they carry information across different parts of the brain.

The link between ST and brain regions involved in language and reading development was examined in a study by Wurzbacher *et al*.[51]. They noticed less activation in the areas linked to important language and reading functions, such as semantic organization and phonological processing.

A different fMRI study by Fumagalli *et al*.[52] investigated how screen media affected preschoolers' visual attention. The intraparietal cortex and the frontal eye fields, two areas linked to visual attention, were found to be more activated when ST increased.

Regarding the correlations between the duration of children's interaction with screens since birth and AP, AM, VP, VM, WM, and emergent literacy scores, we found a significant negative correlation between AP, AM, VP, WM, and emergent literacy and screen use duration in years, but VM showed a non-significant correlation. Our findings were consistent with those of longitudinal studies conducted by Swing *et al*.[53] and Pagani *et al*.[54], who discovered a link between higher levels of television viewing in early childhood and poorer cognitive outcomes in adolescence. These investigations also revealed a link between extended ST and academic difficulties in later years.

The findings support the advice given to parents to limit their preschool-aged children's exposure to ST. A parent should also spend their child's screen time with them. This advice aligns with the American Academy of Pediatrics, which states that children ages two to four should only spend an hour in front of a screen, supervised by their parents.

Strengths of the study:

Unlike earlier research on the relationship between preschool-age screen use and LDs, which relied on unstandardized scales or questionnaires, our study relied on standardized investigation of evidence-based practices, which are connected to various aspects of learning and are both valid and reliable. To determine the degree to which ST is beneficial or detrimental to various forms of memory, we also separated the screen time into three groups and considered the time spent using the device.

Limitations and future directions:

The study included a relatively small sample size from only one location. Thus, researchers would have obtained more extensive and probably more reliable results from future multicentral longitudinal investigations with a larger sample size.

In terms of technology kind, we didn't look at how different types of technology affected learning. A study's materials should be formatted and contain a variety of screens. Doing this would ensure a more potent study methodology, making analyzing data regarding active and passive screen time more accessible and better.

CONCLUSION

Our research extensively examined the association between ST exposure and learning capacities in preschool-aged children. The findings revealed an adverse correlation between high ST and children's emergent literacy, AM, AP, VP, and WM skills. Notably, there were no significant differences observed in VM. Children who exceeded four hours of ST displayed a heightened susceptibility to affection. Additionally, the duration of screen usage over the years exhibited a noteworthy negative correlation with AP, AM, VP, WM, and emergent literacy, though VM did not show any discernible changes.

CONFLICT OF INTEREST

There are no conflicts of interest.

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