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ПСИХОЛОГИЯ РАЗВИТИЯ И ВОЗРАСТНАЯ ПСИХОЛОГИЯ
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Development of executive functions in preschoolers with varying degrees of exposure to the digital environment

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Abstract

Children around the world are spending increasing amounts of time in digital environments, yet data on the impact of this factor on their development remains inconclusive. The article presents a review of research on how digital environment exposure impacts children's executive functions. Contemporary studies demonstrate that the relationship between digital technology use and the development of children's cognitive functions is more mediated and complex than previously believed, particularly regarding executive functions. Most studies indicate that increased screen time is associated with lower executive function performance. At the same time, recent studies question the direct correlation between increased screen time and reduced executive functions, underscoring the importance of assessing both the length and type of digital device usage within the context of family dynamics. Contextual factors related to the influence of children's digital environment exposure on executive functions include: family restrictions on children's digital engagement (rules and duration), parental education level, content quality, passive versus active use of digital devices, and parental mediation of children's device use.

Keywords: cognitive development, digital devices, digital environment, executive functions, preschoolers, screen time

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Формирование исполнительных функций у дошкольников, в разной степени включенных в цифровую среду

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Резюме

Дети во всем мире проводят все больше времени в цифровом пространстве, однако данные о влиянии этого фактора на их развитие остаются неоднозначными. В статье представлен обзор исследований о влиянии пребывания в цифровой среде на исполнительные функции у детей. Современные исследования показывают, что связь между использованием цифровых технологий и развитием когнитивных функций у детей носит более опосредованный и комплексный характер, чем считалось ранее, особенно в отношении исполнительных функций. В большинстве исследований показано, что увеличение длительности экранного времени связано с более низкими показателями исполнительных функций. Вместе с тем современные исследования оспаривают прямую связь между увеличением экранного времени и ухудшением исполни-

тельных функций, подчеркивается необходимость сопоставления времени и характера использования цифровых устройств с семейными условиями. Контекстуальными и связанными с влиянием пребывания ребенка в цифровой среде на исполнительные функции факторами являются: наличие в семье ограничений по пребыванию ребенка в цифровом пространстве (правила и длительность), уровень образования родителей, качество контента, пассивное или активное использование цифровых устройств, опосредование родителем использования цифрового устройства ребенком.

Ключевые слова: дети дошкольного возраста, исполнительные функции, когнитивное развитие, цифровые устройства, цифровая среда, экранное время

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Introduction

Attitudes toward children's exposure to the digital environment can be divided into two periods, mainly to pre- and post-COVID. Before the onset of global restrictions on in-person interaction, most scientific and medical organizations recommended no more than 20 minutes of daily screen time for preschoolers (WHO, 2019). Moreover, the term «digital dementia,» coined by M. Spitzer (Spitzer, 2012), gained rapid traction, and there is now a review of numerous articles describing internet overuse effects in individuals (Ali, Janarthanan, Mohan, 2024). However, it is important to note that the existence of the term does not inherently validate the phenomenon.

With face-to-face interaction being impossible, communication had to rely on digital devices and many preschoolers far exceeded the recommended screen time limits (Nikolaeva, Dunaevskaya, Kalabina, 2021, Uğraş et al., 2023). After the pandemic the habit of spending time in the virtual world persisted for both adults and children. Nearly every contemporary study reports that screen time exceeds WHO guidelines (Nikolaeva et al., 2023). Research shows that despite the rapid adoption of tablets and gaming consoles, television remains children's preferred device, followed by mobile phones in terms of use frequency. Data reveals that children aged 0—6 years spend an average of 92 minutes per day watching TV. Additionally, 92% of them own a tablet and spend on average 60 more minutes per day using a computer or tablet. Most children begin accessing and using computer technology at two years of age (Калабина, Никитина, Николаева, 2024).

While digital content that children engage with has evolved, most researchers concur that interaction with gadgets adversely affects all cognitive processes, as we will explore next.

This situation bears a striking resemblance to the one described by Plato (Plato, 1980) in his dialogue Phaedrus. Socrates asks Phaedrus whether he knows how writing came to be invented. Then Socrates outlines three negative consequences that he believed were the result of the advent of writing. Socrates argued that humans naturally accept written words as truth, yet it is only through dialogue that doubt emerges — a doubt that must be applied to everything in order to distinguish reality from illusion and gain true understanding. Writing destroys memory by replacing it with recollection, making people dependent on written records rather than rely on their own minds. Yet memory is the very foundation of knowledge. Plato describes how Phaedrus, afraid he would forget Lysias' speech, writes it down and hides it under his cloak. This leads Socrates to assert that writing does not aid learning but instead creates the illusion of knowledge. Finally, Socrates recognized that simply reading could foster the illusion of knowledge or even lead to false knowledge; whereas meaningful understanding requires mediation between text and learner. A teacher can be such mediator guiding the learner's understanding to greater depth while carefully regulating information according to the learner's capacity.

Socrates' concerns about then-new technology remain profoundly relevant to what is, for us, a new technology: a child's exploration of the world through digital engagement. We must remember that only by mastering the real world can a child effectively navigate the digital one. Children should not accept online texts as absolute truth but must learn to question them. We can teach children internalize knowledge rather than simply remember where to find it online. Finally, as children engage with the digital world, there must always be an adult mediator to guide them and to direct the child's attention to the information depth uncovering subtext, associations, and metaphors. This mediation expands textual understanding while shaping the child's developing worldview.

An analytical review involves examining data based on relevant theoretical frameworks. Therefore, our examination of how executive functions develop in relation to digital exposure will begin with theoretical conceptions of executive function development. This approach will help address potential contradictions in existing research findings.

Executive functions represent a set of cognitive tools that enable the shift from habitual to novel behaviors — essentially forming the basis of everyday learning (Hauptman, Liu, Bedny, 2024; Badre, 2025). As such, they constitute the

highest level of organism adaptation, spanning from biological processes to behavioral modification. At the same time, they regulate lower-level cognitive processes (attention, perception, memory, etc.) while also laying the basis for more complex cognitive operations like goal-setting and planning (Diamond, 2013). Research has demonstrated that the strength of executive functions in childhood predicts later academic success (Quílez-Robres, Moyano, Cort s-Pascual, 2021), particularly in mathematics (Emslander, Scherer, 2022).

Early studies established that the efficiency of executive functions depends on prefrontal cortex maturity. A. Diamond showed that prefrontal cortex development drives changes in executive functions (as measured by the A-not-B task) within the first year of life (Diamond, Goldman-Rakic, 1989). Diamond's work is particularly groundbreaking. She was the first to demonstrate the nonlinear nature of executive function development — that is, the presence of both rapid progressions and phases of slowed formation. Subsequent studies have consistently observed these non-linear developmental trajectories across all ages.

Moreover, evidence shows executive functions are especially vulnerable to external influences, particularly negative ones, during early childhood (Ramos et al., 2023; Dydenkova et al., 2024). Conversely, physical exercise in childhood has been shown to enhance executive function performance (Zeng, Lee, Gao, 2023; Wei et al., 2024).

In particular, it has been demonstrated that working memory and inhibitory control develop independently during the preschool years (Разумникова, Николаева, 2021). However, with the onset of formal schooling (which systematically engages and structures cognitive processes) these functions begin to show significant correlation and mutual reinforcement (Nikolaeva, Isaiko, Soboleva, 2020). This developmental pattern strongly resembles the situation where, according to L.S. Vygotsky's theory (1966) and actually observed phenomena, speech and thinking initially develop along parallel tracks, but during the period of active speech development, speech begins to influence thinking, while thinking enhances the use of speech in cognition.

A. Miyake and N. Friedman (Miyake, Friedman, 2012) found individual differences in executive functions (EFs) as measured through simple laboratory tests. EFs:

(a) demonstrate both unity and diversity (while different EFs intercorrelate, they remain separable),

(b) reflect significant genetic contribution,

(c) are associated with various clinically and socially significant phenomena,

(d) show certain developmental stability.

It is evident that the observable nonlinear progression of behavioral development has internal determinants that are parameters of biological processes, among which prefrontal cortex myelination is recognized as the primary one. Also there are physiological laws that help explain the nonlinearity of executive function development. According to Son'kin's concept (Son'kin, 2015), the maturation of specific neural structures, and consequently physiological functions, does not occur chaotically but sequentially, step by step, during specific time intervals from conception. Here too, the corresponding maturation periods for each function approximately coincide across all individuals. This is how the algorithm of age-related transformations works, executed under the control of the genetic apparatus of each cell in a multicellular organism. The uneven pace of growth and development represents an essential and consistent feature of the unfolding ontogenetic program.

It is important to emphasize that the *growth* and *development* are not synonymous terms but rather represent fundamentally distinct processes. Development involves functional organization becoming more complex. Growth refers to the increase in an organism's biomass. At the cellular level, growths manifests through proliferation, i.e., expansion of cell size and/or numbers. Development involves differentiation where cells acquire novel properties and gain new functional capabilities. However, emerging research increasingly demonstrates how social environment shapes executive function development (Koşkulu-Sancar et al., 2023).

These developmental characteristics of executive functions may skew research outcomes when studies examine small child cohorts of overly narrow age ranges without accounting for physiological parameters (beyond cognitive measures).

Materials and methods

In the first phase of the study, we conducted an analytical review of theoretical conceptions of executive functions. This was followed by a systematic review. We conducted a systematic literature search across scientific databases PubMed and ScienceDirect, searching for keywords: *screen time, digital, children, cognitive development, executive functions* (2019-2024). Systematic reviews are defined as secondary research or syntheses of evidence focused on a specific question that based on a structured methodology and make it possible to identify, select, critically appraise, and summarize findings from relevant studies (Sgarbossa et al., 2022).

We included the term *cognitive functions* in our search criteria since it sometimes encompassed *executive functions* as well. In total, under the specified conditions, ScienceDirect returned 1,398 entries and PubMed returned 8 entries. We then analyzed sources that, in the authors' judgment, most clearly demonstrated the impact of digital technologies (internet, digital devices, applications, and software) on the development of executive functions and cognitive abilities in preschool, elementary school, and adolescent children. Only open-access, full-text articles were considered. Ultimately, 121 publications were reviewed.

We deliberately excluded studies linking executive functions and screen time to parental stress during the COVID-19 pandemic (Almeida et al., 2023). Introducing parental stress as an additional influencing factor — which is no longer prevalent — could disproportionately affect results, potentially overshadowing other variables and complicating the generalization of findings to normal conditions.

The impact of the digital environment on children's executive functions

We begin by analyzing 14 studies published between 2019 and 2024 (table).

One of the most comprehensive meta-analyses (Whitlock, Masur, 2019), examining screen time and cognitive functions from 1960 through March 2019, included data from 480,479 participants aged 4 to 18 years. This work traces concerns about the relationship between screen time and children's development, health, and productivity back to the advent of television screens. The earliest research on this topic was conducted in 1949 by Columbia Broadcasting System (now CBS Corporation) in collaboration with scientists from Rutgers University. That study found that television ownership strengthened family bonds, and that watching TV programs was not a passive consumption but a discussion-based pastime of family members. However, the 2019 analysis (conducted when televisions had long become household staples, typically present in every room) yielded different results. The authors established the necessity of analyzing different screen activities separately, as the combination of television screen time and gadget screen time was unevenly distributed. Time spent watching television programs and playing video games (which can now also be displayed on TVs through consoles) showed the most pronounced negative correlation with children's academic performance. However, the study importantly highlights the significance of both the content presented on electronic devices and the purpose of its use.

Table

Characteristics of studies included in systematic review

Author, year	Study sample	Study design	Key Findings Related to EF
Whitlock, Masur, 2019	480479 participants aged 4 to 18 years (data from 1960 to 2019)	Meta-analysis	Each type of screen-time activity must be analyzed separately. While direct data on EF is not presented, the most significant negative association was found between TV viewing/video gaming and academic achievement. The impact is determined not by the device itself, but by the content consumed and the purpose of its use
McHarg et al., 2020	179 infants at 24 and 36 weeks	Longitudinal	Regular screen exposure at 4 months predicted poorer inhibitory control
Corkin et al., 2021	3787 families, (children 2 and 4 years of age)	Longitudinal	Higher weekday TV exposure at 2 was negatively associated with "hot" EFs at 4.5 years. Child eating meals in front of TV at 4 was associated with poorer "cool" EFs at 4.5 years
Helm, 2022	70 children aged 3,5 to 5 years	Experimental	A short-term decline in go/no-go task accuracy (inhibitory control) after 15 minutes of tablet use compared to toy play
Horowitz-Kraus et al., 2024	51 children 4 years of age, parents	EEG study	Longer screen exposure was associated with lower EF in children and their parents. Home literacy environment was positively associated with EF's neurobiological (EEG) and behavioral measures
Bustamante et al., 2023	6922 participants aged 0—6 years	Meta-analysis	No statistically significant correlation between total screen time and EFs. The necessity of considering content and context of use, rather than solely the duration of screen exposure was emphasized
Portugal et al., 2023	46 children at age 3,5 years	Longitudinal	More than 15 minutes of screen time per day was linked to poorer working memory. This association disappeared when background TV was considered. Viewing non-child-directed content on TV was associated with reduced inhibitory control
Mallawaarachchi et al., 2024	7441 children aged 0 to 5,99 years	Systematic review and meta-analysis	Program viewing and background television were negatively associated with cognitive outcomes, while program viewing, age-inappropriate content and caregiver screen use during routines were negatively associated with psychosocial outcomes. Co-use was positively associated with cognitive outcomes
Veraksa, Rodova, 2025	115 children aged 5 to 6 years	Correlation analysis	An association between working memory capacity and the presence of household rules restricting digital devices use was found
Lakicevic et al., 2025	1,016 children aged 5—6 years	Correlation analysis	The analysis revealed weak negative correlations: both active and passive screen time with lower cognitive flexibility, and passive screen time with poorer verbal memory and inhibitory control
Maeneja et al., 2025	231,117 children	Systematic review	In 8 out of the 10 reviewed studies, an increase in screen time was associated with a decline in EF. In the two studies where no significant effect was found, this result was explained by the practice of co-using devices with parents or siblings. These findings confirm the importance of parental mediation and shared use of digital devices

Author, year	Study sample	Study design	Key Findings Related to EF
Sutormina et al., 2025	40 children aged 5—7 years	Correlational study utilizing cluster analysis	Children with higher inhibitory control were characterized by restricted digital devices use (< 1 hour per day) and having older fathers

Таблица

Характеристика исследований, включенных в систематический обзор

Автор, год	Выборка	Дизайн исслелования	Ключевые выводы, касающиеся исполнительных функций
Уитлок, Масур, 2019	480479 участников в возрасте от 4 до 18 лет (данные с 1960 по 2019)	Мета-анализ	Каждый тип деятельности, связанный с экранным временем, должен анализироваться отдельно. Несмотря на отсутствие прямых данных об исполнительных функциях, наиболее значимая негативная связь была выявлена между просмотром телевизора/видеоиграми и академической успеваемостью. Влияние определяется не фактом использования цифрового устройства, а потребляемым контентом и целью его использования.
Макхарг и др., 2020	179 младенцев в возрасте 24 и 36 недель	Лонгитюдное	Регулярное использование цифровых устройств в возрасте 4 месяцев являлось предиктором более низкого тормозного контроля.
Коркин и др., 2021	3787 семей, (дети от 2 до 4 лет)	Лонгитюдное	Более продолжительный просмотр телевизора в будние дни в возрасте 2 лет демонстрировал отрицательную связь с развитием «горячих» исполнительных функций в 4,5 года. Приём пищи ребёнком перед телевизором в возрасте 4 лет был связан с менее развитыми «холодными» исполнительными функциями в 4,5 года.
Хелм, 2022	70 детей в возрасте от 3,5 до 5 лет	Экспериментальное	Зафиксировано кратковременное снижение точности выполнения задачи «Go/No-Go» (тормозный контроль) после 15 минут использования планшета по сравнению с игрой в игрушки.
Хоровиц-Краус и др., 2024	51 ребенок в возрасте 4 лет, родители	ЭЭГ исследование	Более длительное экранное время связано с низким уровнем развития исполнительных функций как у детей, так и у их родителей. Качество домашней образовательной среды положительно коррелировало с нейробиологическими (ЭЭГ) и поведенческими показателями исполнительных функций.
Бустаманте и др., 2023	6922 участников в возрасте 0—6 лет	Мета-анализ	Не выявлено статистически значимой корреляции между экранным временем и развитием исполнительных функций. Подчёркивается необходимость учитывать прежде всего контент и контекст использования цифровых устройств, а не только продолжительность экранного времени.

Research specifically examining executive functions in relation to children's digital media exposure remains limited. A longitudinal study by McHarg (McHarg et al., 2020), employing propensity score matching with 179 infants at 24 and 36 weeks, found that regular screen exposure at 4 months — regardless of duration — predicted poorer inhibitory control, though showed no association with working memory or cognitive flexibility.

It's essential; to note that screen exposure effects differ fundamentally in infancy and at later ages. Infants cannot process information presented on screens for more than 3—5 seconds (Kirkorian, 2018). Furthermore, children under two cannot comprehend even age-appropriate content. This suggests that all infant screen exposure effectively constitutes adult-oriented content and/or background media. The common conclusion of such studies emphasizes the importance of media content (O'Toole, Kannass, 2021) and the phenomenon of delayed speech development associated with early intensive screen exposure, termed the «digital bubble» (Bochicchio et al., 2022).

Collectively, these data indicate transient «state-like» effects on EFs—that is, effects that are short-term and may be related to a third variable such as the child's mood or attention span, and will quickly disappear — but say nothing about the impact on individual differences in chronic or persistent «traits» — that is, effects that endure longer and may have negative long-term consequences.

Several studies have identified factors that may mitigate the negative impact of gadget use on children's cognitive development. For example, research shows that there are no adverse effects from gadget use in children under 3 years of age when their parents have higher education (Brauchli et al., 2024).

The study by Mallawaarach-chi et al. (2024) comprised both: a systematic review and meta-analysis. Sources were reached on the PsycINFO, Embase, MEDLINE Ovid, ProQuest, CINAHL, Web of Science, and Scopus were

searched from 2021 to December 31, 2023. Overall, 100 studies (176 742 participants) were included, and of these, 64 observational studies (pooled sample sizes ranging from 711 to 69 232) were included in meta-analyses. The data analysis indicates that passive or non-engaged viewing of screen-based content, as well as extended digital device use, are more commonly linked to negative outcomes. Conversely, engagement with educational content and joint digital device use with an adult are associated with fewer adverse effects and may support the development of executive functions. More recent studies are increasingly skeptical regarding digital technology's straightforward impact on cognitive functioning — and specifically on children's executive functions. Researchers emphasize the need to contextualize findings within family dynamics, suggesting that there may be a non-linear relationship between screen time and attentional function (Liebher, 2022; Veraksa et al., 2022).

One of the early studies in this group examines the impact of gadget use among 5-6-year-olds through the lens of cultural-historical theory (Выготский, 1966). In this framework, digital devices are of particular interest because they function simultaneously as physical tools and cognitive-psychological means. This is precisely why the effect on cognitive functions depends on the nature of the activity during gadget use (Veraksa et al., 2022).

The results demonstrate a link between how children engage with gadgets and their performance on executive function tests (inhibitory control, cognitive flexibility, working memory). Significant predictors associated with diminished executive functions include: frequency and duration of gadget use (more than 1 hour per day), passive rather than active engagement with the device, lack of adult-guided discussion about content.

One of the most cited articles from the examined period is the paper by M. Corkin (Corkin et al., 2021), describing research conducted as part of the Growing Up in New Zealand project. The authors explored correlations between screen media use and the development of «hot» (emotionally-driven) and «cold» (cognitive) executive functions.

The sample consisted of 3,787 families, with all members surveyed. The study analyzed the developmental features of children's executive functions at 2 and 4 years of age. The impact of screen time duration (less than 2 hours or more than 2 hours per day), content orientation (child-directed or adult-directed), background TV exposure versus intentional screen use, and the purpose of screen use (educational or during meals) were assessed. Additional factors evaluated were screen time restrictions and frequency of adult-child co-viewing of children's programs. Binary logistic regression analysis yielded the following results:

• For 2-year-olds, prolonged TV exposure (more than two hours) on weekdays led to poorer «hot» EF scores at age 4.5 years.

• At age 4, the habit of eating while watching TV correlated with lower «cold» EF levels at 4.5 years.

Although devices such as phones, tablets, and computers can be beneficial for learning, their excessive use may negatively affect preschoolers' cognitive functions. Given the limited data on this age group, Helm's (Helm, McDermott, 2022) study aimed to explore the relationship between screen time (ST) and executive functions in children aged 5—6 years.

The study involved 70 children aged 3,5 to 5 years. First, they completed an age-adapted go/no-go task, after which they were randomly assigned to either a technology group or a control group. Technology group children performed a tablet-based food cooking game for 15 minutes. Control group children completed a similar task using physical toys (without a tablet) for the same duration.

Afterward, the children repeated the go/no-go task. The results showed that children in the technology group exhibited lower inhibitory control compared to the control group, reflected in reduced accuracy during the go/no-go task after tablet use. However, post-error slowing (a delay in response following a mistake) was observed in both groups. The authors conclude that even short-term tablet use may lead to selective cognitive impairments in young children shortly after use. As with earlier studies, these results do not provide definitive conclusions about the long-term effects of gadget-based tasks.

Many studies not specifically related to executive functions demonstrate the influence of family factors on preschoolers' cognitive development (T ren, Kahraman, 2025). Far fewer studies focus on executive functions, yet some research does exist. One such study examined the impact of Home Literacy Environment, screen time duration, and parental executive functions on the development of these functions in 4-year-olds (Horowitz-Kraus et al., 2024). Children's electroencephalograms (EEG) were recorded during the Attention Network Task (ANT). It was found that longer screen time was associated with poorer executive functions in both children and their parents. Higher child EF scores correlated with better parental EFs. The more time children spent in front of screens, the lower the EF scores in both parents and preschoolers. Additionally, lower child EF scores reduced the likelihood of parents read books to him or her.

The study confirms the importance of Home Literacy Environment and screen time restrictions for children's executive function development. It also highlights the role of familial predisposition (parental EFs) in shaping a child's cognitive abilities.

The study by J.-C. Bustamante et al. (Bustamante, Fern ndez-Castilla, B., Alcaraz-Iborra, 2023) provides a meta-analytic synthesis of existing data on the relationship between total screen time (TV and gadgets) and EFs in preschool children.

A systematic search was conducted in Web of Science and EBSCO databases to identify relevant studies published before January 2023. The analysis included 15 articles with a total of 6,922 participants aged 0—6 years. The roles of gender, age, and active versus passive screen interaction in determining the impact on EFs were assessed. No statistically significant correlation was found between total screen time and EFs or between the selected analysis parameters. Nevertheless, the study emphasizes the need to account for other contextual and developmental factors to determine

the overall impact of screen time on children's EFs. The authors stress that digital device use should be active rather than passive and occur in the presence of significant adults. Furthermore, this work highlights the necessity of further research into the influence of various factors and aspects of screen use (not just duration) on executive function development, including content analysis.

The authors argue that since screen time may influence future health outcomes, education and public health professionals should consider monitoring and restriction as regulatory strategies to prevent disruptions in the natural development of executive functions in children under 6 years of age. However, to develop accurate recommendations for families, educators, and health policymakers, more in-depth research is needed on the consequences of excessive digital media use and its connection to early executive function development.

One such longitudinal study examined the relationship between touchscreen usage time and two EF components: working memory/cognitive flexibility, and impulsivity/inhibitory control (Portugal et al., 2023). Low screen time was classified as less than 15 minutes per day, while high screen time exceeded 15 minutes daily.

The sample comprised 46 children (23 girls) initially tested at age 3,5 years and reassessed 12 months later. Children with more than 15 minutes of daily screen time demonstrated lower working memory scores compared to those with less screen exposure. However, when background television exposure was accounted for, significant between-group differences disappeared. Inhibitory control decreased when children watched non-child-oriented TV content. A key finding emphasized the necessity of including background TV in analyses.

By early 2025, core conclusions emerged suggesting that for optimal EF development weekday screen time (including TV and devices) should be limited to 1 hour for preschoolers. However, the decline in executive functions appears less dependent on gadget usage duration and more strongly linked to Home Literacy Environment characteristics. Home environment is shaped by parental attitudes toward cognitive development and related practices: regular book reading, screen time monitoring, and discussing with children the digital content they have watched or heard.

Research from 2025 is presented in a separate section because the year has not yet concluded. By June 2025, we identified four studies specifically examining EF development in preschoolers (0—6 years) within digital environments (Table 1).

A.N. Veraksa and S.D. Rodova publication (Veraksa, Rodova, 2025) explored digital device use among older preschoolers in relation to regulatory function development, accounting for parental burnout and parents' involvement in children's device use. Participants included 115 children (61,7% boys, 38,3% girls; M age = 5,8 years, SD = 3,628) from Moscow kindergartens and their parents. EF assessment tools included NEPSY-II diagnostic set («Sentences Repetition,» «Memory for Designs», «Inhibition», «Statue» subsets) and Dimensional Change Card Sort. To examine patterns of digital device usage among preschoolers, a parent questionnaire was developed, assessing key parameters such as usage frequency and household rules on digital device use. Parents also completed Parental Burnout Assessment (Roskam, Brianda, Mikolajczak, 2018).

Results showed that working memory capacity correlated with household time restrictions for digital exposure. Parental burnout showed no significant effects on any of the examined parameters.

Lakicevic et al. (Lakicevic et al., 2025) assessed EFs in 1,016 children aged 5—6 using the Developmental Neuropsychological Assessment (NEPSY-II) and Dimensional Change Card Sort for cognitive flexibility (CF), visual/verbal working memory (WM), inhibition, and motor persistence. Parents completed questionnaires about their children's screen time. On average, children spent approximately 2 hours per day actively and passively engaged with digital devices. Boys spent more time on active uses (games/apps) than girls. Weak negative correlations were found between screen time (both active and passive) and cognitive flexibility, as well as between passive screen time and verbal working memory. The duration of passive screen exposure on weekdays weakly correlated with inhibitory control. The study concludes that it is necessary to limit screen time (no more than 1 hour per day) and to prioritize content that stimulates active interaction with devices. An additional recommendation drawn from the literature states that children require daily physical activity.

In addition to individual studies, a 2025 review (Maeneja, Rato, Ferreira, 2025) synthesized research from 2022—2024 assessing the impact of information and communication technologies on executive functions in children and adolescents. Literature was collected from PubMed, Scopus, and Cochrane Library databases. Due to the heterogeneity of results, a narrative synthesis was conducted. The analysis included 10 studies with a total of 231,117 children from nine countries across three continents. The findings were consistent with all prior data indicating that increased time spent in digital environment reduces the development of all executive functions. In 2 out of the 10 studies, no decline in executive functions was observed, which was attributed to co-use of devices with parents or siblings.

Our forthcoming study (Сутормина, Калабина, Николаева, 2025, in print) involved 40 children (25 girls, 15 boys). EF assessment included go/go and go/no-go paradigms, and visuospatial working memory (Rasumnikova, Nikolaeva, 2021). Python's Scikit-learn library facilitated data analysis. Cluster analysis was performed on the obtained data, using regression and factor analyses. It was found that all children could be divided into three clusters based on their performance on executive function assessments. Cluster 1 included children with the highest level of inhibitory control and an average level of working memory development. Cluster 2 children were distinguished from other clusters by their high working memory capacity. Cluster 3 children showed low scores in both inhibitory control and working memory. It was demonstrated that children with the highest level of inhibitory control had limited weekday gad-

get use (no more than one hour per day). Moreover, their fathers were the oldest in the sample.

Conclusions

Based on the analysis, the following key conclusions can be made:

— absence of a direct linear relationship: Current research does not support a simple correlation between increased screen time and lower EF. The impact of digital environments appears to be complex and influenced by multiple factors;

— the critical role of context and content: Passive use of digital devices, exposure to age-inappropriate content, and absence of adult co-viewing and discussion are linked to negative effects on EF;

— screen time guidelines: Despite the multifaceted nature of digital influence a consensus persists regarding the need to limit screen time for preschoolers to no more than one hour per weekday.

— family and adult mediation: EF development shows a stronger correlation with the overall educational and cultural environment within a family rather than with the simple fact of digital device use;

— research direction: Future studies should consider the quality, context, and content of digital activity and consider diverse family and environmental factors, rather than focusing solely on duration.

The findings regarding the impact of digital environments on the development of executive functions in children align with the principles of information engagement once proposed by Socrates and described by Plato. An adult must mediate between the child and the device, ensuring that the content is age-appropriate and limiting exposure in a way that allows the child sufficient time to comprehend the world through real-world experiences. Furthermore, all content consumed by the child through digital devices should be discussed in dialogue with an adult. Regardless of the information source — whether the physical environment, books, or digital media — clear guidelines must govern how the child interacts with that information, and the content must be carefully reviewed and processed alongside a significant adult.

Limitations. The study scope is limited as it describes and reviews publicly available research and full-text guidelines.

Краткое изложение содержания статьи на русском языке

Введение

В научной литературе, как и в обыденном сознании многих людей, сложились крайне противоречивые представления о пребывании ребенка в цифровом пространстве (Kalabina et al., 2024). С нашей точки зрения, наиболее точный ответ о роли гаджетов в формировании когнитивных процессов ребенка можно получить из обзора исследований, в которых рассматривалось влияние взаимодействия ребенка с гаджетами на формирование исполнительных функций.

Исполнительные функции (ИФ) — совокупность когнитивных инструментов, отвечающих за изменение поведения от привычного к новому, т. е. они лежат в основе ежедневного обучения человека (Badre, 2025; Hauptman, 2024). В тоже время они сами управляют когнитивными процессами более низкого уровня (внимание, восприятия, память и т.д.) и одновременно закладывают основу более сложных когнитивных процессов, таких как целеполагание и планирование (Diamond, 2013). Доказано, что состояние ИФ в детстве позволяет предсказать успешность обучения в школе (Quílez-Robres et al., 2021), прежде всего в освоении математики (Emslander, Scherer, 2022).

А. Даймонд показала, что созревание префронтальной коры предопределяет изменения ИФ (оцененное в решении задачи А-не-Б) уже в первый год жизни, и это изменение происходит нелинейно (Diamond, Goldman-Rakic, 1989). Эти функции особенно чувствительны к внешнему воздействию, прежде всего негативному, в первые годы жизни (Ramos et al., 2023; Dydenkova et al., 2024). Было показано, что рабочая память и тормозной контроль в дошкольном возрасте формируются независимо (Nikolaeva et al., 2021).

Неравномерность процессов роста и развития представляет собой фундаментальную закономерность, неуклонно действующую в процессе разворачивания генетической программы онтогенеза (Son'kin, 2015). Однако все больше работ, которые свидетельствуют о влиянии социального окружения на развитие исполнительных функций (Koşkulu-Sancar et al., 2023).

Все эти особенности развития исполнительных функций могут влиять на результаты исследования, если изучается небольшая группа детей очень узкого возрастного диапазона без связи с параметрами, отражающими в той или иной мере физиологические показатели, кроме когнитивных.

Материалы и методы

В рамках систематического обзора были использованы методы библиографического анализа научных баз данных PubMed, ScienceDirect (поиск по ключевым словам: screen time, digital, children, cognitive development executive functions за 2019—2024 годы).

В общей сложности по заданным условиям на платформе ScienceDirect было предложено 1398 записей, на платформе PubMed-8. Далее анализировались источники, которые, по мнению авторов, наиболее явно представляют воздействие цифровых технологий (Интернет, цифровые устройства, игровых приложения и программы) на развитие ИФ и познава-

тельной сферы детей дошкольного, младшего школьного и подросткового возраста, с открытым доступом к полнотекстовым версиям. В итоге были рассмотрены 14 статей.

Результаты

Работы, связанные исключительно с ИФ функциями у ребенка, пользующегося гаджетами, единичны. Макхарг с соавторами (2020) провели лонгитюдное исследование младенцев в возрасте 24 и 36 недель (179 детей) и обнаружили, что при прочих равных условиях регулярное воздействие экранов в любом количестве в 4 месяца было связано со снижением уровня тормозного контроля в более позднем возрасте. Общим итогом подобных работ является значимость содержания, которое предъявляется ребенку с помощью гаджета (O'Toole, Kannass, 2021).

Есть статьи, которые обнаруживают факторы, которые могут снизить негативный эффект использования гаджетов на когнитивное развитие детей. Так показано, что нет негативных последствий при использовании гаджетов детьми до 3 лет у родителей с высшим образованием, устанавливающих правила получения ребенком гаджета (Brauchli et al., 2024).

В работе Маллаварачи с соавторами (2024) были проведены как систематический анализ, так и метаанализ. Главный вывод, сделанный при изучении данных, состоял в том, что негативные последствия чаще проявляются при пассивном просмотре любого экранного контента, а также при длительном пребывании в цифровой среде. При этом качественный образовательный контент и совместное со взрослым использование гаджетов не только смягчают негативные эффекты, но, напротив, способствуют лучшему формированию ИФ.

Чем позднее проводились исследования, тем выраженнее были сомнения в простом и негативном влиянии цифровых технологий на когнитивную сферу ребенка, в том числе конкретно на исполнительные функции детей. Говорится о необходимости сопоставления данных с ситуацией в семье, а также обязательного учета нелинейной связи между количеством времени, проводимого перед экраном, и функцией внимания (Liebher, 2022; Veraksa et al., 2022).

Выявлены значимые факторы, предопределяющие снижение уровня ИФ при использовании гаджетов:

- частота и длительность использования гаджета (более 1 часа в день);
- пассивный, а не активный тип его применения;
- обсуждение содержания контента со взрослыми (Corkin et al., 2021).

Исследование Ж.-К. Бустаманте с соавторами (2023) показали, что дети, проводившие у экрана больше 15 минут в день, демонстрировали по сравнению с детьми с меньшей включенностью в экранное время, более низкие показатели рабочей памяти. Однако, если учитывалась фоновая работа телевизора, значимые различия между группами исчезали. Тормозной контроль снижался, если дети просматривали программы недетского содержания по телевизору. Значимым выводом была необходимость включать в анализ фоновую работу телевизора.

Заключение

На основе проведенного анализа можно сформулировать следующие ключевые выводы.

Отсутствует прямая линейная зависимостьи: современные исследования опровергают простую прямую связь «больше экранного времени = ниже уровень ИФ». Влияние цифровой среды сложное и опосредованно множеством факторов.

Отмечается роль контекста и содержания: наибольшее негативное влияние на ИФ оказывает пассивное использование цифровых устройств, просмотр контента несоответствующего возрасту, отсутствие обсуждения увиденного со взрослым.

Несмотря на опосредованный характер влияния, сохраняется консенсус о необходимости ограничивать экранное время для дошкольников (не более 1 часа в будние дни).

Отмечается ключевая роль семьи и взрослого как посредника: развитие ИФ сильнее связано с общей образовательной и культурной средой в семье, чем с самим фактом использования цифровых устройств.

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