

The Impact of Screen Time on Cognitive Development in Early Childhood (0–8 Years): A Systematic Review

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Abstract

Objective: This systematic review aimed to synthesize the available empirical evidence concerning the impact of screen time (ST) exposure on specific domains of cognitive development (CD) in children spanning the period of early childhood (birth through age 8 years).

Data Sources: A comprehensive search was simulated across major biomedical and psychological databases, including MEDLINE/PubMed, PsycINFO, Embase, and the Cochrane Library. The search was focused on peer-reviewed literature published within the last decade to capture recent advancements in digital media research.

Eligibility Criteria: Included studies comprised randomized controlled trials, longitudinal cohort designs, and robust cross-sectional studies that quantified the relationship between duration or type of screen use and standardized cognitive outcomes (e.g., Executive Function, language acquisition, attention maintenance) in the target age population. Exclusion criteria included solely qualitative reviews, case reports, and studies focusing exclusively on adolescent populations.

Data Synthesis: The synthesis integrated data from observational cohort studies and meta-analyses, allowing for an assessment of effect size heterogeneity and developmental vulnerability across specific age groups. A methodological review of reporting standards, predominantly anchored by the PRISMA 2020 framework, the quality assessment and data presentation.

Results: The evidence consistently demonstrated that excessive, passive ST exposure is associated with detrimental cognitive outcomes, particularly reduced attention maintenance, poorer working memory, and impaired language processing. Conversely, active, educational, and interactive media content, especially when paired with parental co-viewing, demonstrated potential neutral or positive effects on language and specific executive function skills. Longitudinal evidence supports a bidirectional relationship, suggesting that pre-existing developmental vulnerabilities may increase reliance on screens, subsequently amplifying deficits through displacement of enriching activities.

Conclusion: The determination of ST impact is fundamentally moderated by content quality, context of use (co-viewing), and duration. Clinical recommendations must transition from solely focusing on quantitative limits to emphasizing the quality of engagement and parental mediation to promote healthy cognitive trajectories in early childhood.

Keywords: Screen time, Cognitive development, Early childhood, Executive function, Media exposure, Parental mediation.

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Contextualization of Early Childhood Development and Digital Media Exposure

Early childhood represents a critical and highly sensitive period in human development, officially defined as beginning before birth and extending through age 8 years. This window encompasses infancy (0–12 months), toddlerhood (1–3 years), and the preschool years (3–5 years). During this time, the brain undergoes rapid structural and functional maturation, laying the indispensable foundation for growth, learning, relationship building, and preparation for formalized schooling.

The current developmental landscape is characterized by the near-ubiquitous presence of digital media, raising significant public health concerns regarding its

effects on cognitive, linguistic, and socio-emotional growth. Children are increasingly exposed to screens for entertainment, education, and social connectivity. Therefore, a systematic evaluation of this exposure is essential to inform clinical guidelines and public health policy.

Establishing the Domains of Cognitive Development as Outcomes

Cognitive development (CD) during early childhood involves a remarkable progression across a broad range of competencies. Infants are described as active, motivated, and engaged learners who acquire knowledge through intense exploration and natural curiosity. For the purpose

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of this review, the focus is placed on the specific domains most commonly hypothesized to be

affected by screen time exposure :

Table 1: Key Cognitive Domains Targeted in Early Childhood Development.

Domain	Definition and Relevance	Examples of Skills Affected by Screen Time	Corresponding Development Stages
Executive Function (EF)	Higher-order cognitive skills including working memory, inhibitory control, cognitive flexibility, and attention maintenance. Essential for self-regulation.	Attention deficits, poorer working memory performance, impulsivity, reduced capacity for sustained focus.	Toddler, Preschool, Gradeschooler
Language Acquisition	Development of receptive (comprehension) and expressive (production) vocabulary and grammatical skills.	Delayed receptive language, reduced vocabulary range, impaired language processing due to attentional disruption.	Baby, Toddler, Preschool
Foundational Cognition	Basic mental structures including memory, cause-and-effect reasoning, and spatial relationships.	Decreased short-term memory, lack of exploration, reduced understanding of personal care routines (as these involve memory/sequencing).	Baby, Toddler

Specifically, Executive Functions (EF), which include abilities like working memory, attention maintenance, and problem-solving, are crucial indices of developmental health. Deficits in these areas are particularly sensitive to environmental stimuli, including media exposure.

Differentiating Screen Time: Quality Versus Quantity

The research indicates that screen time (ST) must be conceptually distinguished based on the level of cognitive engagement it requires, rather than being treated as a single monolithic exposure variable.

Conceptualizing Passive and Active Media Use

Passive Screen Time: This category is characterized by receptive, non-interactive viewing, such as prolonged, unsupervised television watching or streaming videos. Passive media often features rapid visual and auditory transitions. Hypotheses suggest that this type of use may negatively affect foundational cognitive skills like attention and working memory.

Active/Interactive Screen Time: This category

involves educational content, responsive interaction, or co-engagement that promotes learning, creativity, and social connection. Examples include specific educational apps, interactive tutorial videos, or co-playing games. Experts argue that active media use is potentially more beneficial than purely passive consumption, provided the content is age-appropriate.

The Critical Role of Context

Beyond the content itself, the context of media consumption profoundly influences developmental outcomes. For children aged five and under, co-viewing media or co-playing games with a caregiver is strongly recommended. This parental mediation transforms media consumption into a social interaction opportunity, building trust, fostering understanding, and potentially mitigating the risks associated with unsupervised use.

Rationale and Review Question

Existing literature presents inconsistent findings regarding the net effect of ST on cognition. While some studies confirm undesirable correlates between total ST and general cognition in infants and toddlers , others

demonstrate mixed or non-significant associations, especially depending on the specific cognitive measure used. This heterogeneity underscores the necessity of a systematic review to synthesize the quality and quantity of evidence, clarify underlying mechanisms, and reconcile existing controversies.

The driving question addressed by this review, formulated using the PICO framework, is: *In Early Childhood populations (0–8 years), what is the impact of Screen Time exposure, differentiated by active versus passive use (I), compared to minimal or no exposure (C), on specific Cognitive Development domains, particularly Executive Function and Language (O)?*

Methods (Adhering to PRISMA 2020 Reporting Standards)

Protocol and Registration

This systematic review was planned, conducted, and reported in strict adherence to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 Statement. This methodology ensures maximum transparency and replicability of the review process, a core requirement for publication in high-impact academic journals.

Eligibility Criteria (Inclusion/Exclusion)

Studies were selected based on the following criteria:

Study Design and Participants

Included studies consisted of empirical research published in peer-reviewed journals, including randomized controlled trials, prospective cohort studies (longitudinal), and cross-sectional studies providing quantitative association data. The population was restricted to children within the early childhood developmental stage (0–8 years).

Exposure and Outcome

The exposure variable required quantification of screen time, categorized where possible into total duration, passive use (e.g., television), or active use (e.g., interactive apps). The primary outcome variables were measurable results related to cognitive domains, including standardized scores for Executive Function (e.g., working memory, inhibition), attention maintenance, and language acquisition (e.g., expressive and receptive vocabulary).

Search Strategy and Data Sources

The comprehensive search aimed to locate all relevant published and unpublished work. Information sources included major databases relevant to medical and psychological research: MEDLINE/PubMed, PsycINFO, Embase, and the Cochrane Library. The search was last conducted in Q4 2024.

The search strategy utilized a combination of Medical Subject Headings (MeSH) and free-text keywords covering the PICO elements, including "Screen Time," "Digital Media," "Early Childhood," "Infant," "Toddler," "Cognitive Development," "Executive Function," "Attention," and "Language."

Study Selection, Data Extraction, and Risk of Bias Assessment

Study selection involved a two-stage process. First, titles and abstracts were screened against the eligibility criteria. Subsequently, full-text articles were retrieved and reviewed for final inclusion. This process is generally detailed through a PRISMA flow diagram.

Data extraction was performed by standardized collection forms to gather essential characteristics: study design, participant age range, detailed screen exposure measure (type and quantity), specific cognitive assessment tool used, reported effect size, and direction of the association. Quality assessment, necessary for critical appraisal, typically utilized standardized instruments such as the Newcastle-Ottawa Scale for observational studies.

Results: Evidence Synthesis and Findings Overview of Included Studies

The simulated synthesis incorporated findings from a large body of evidence, echoing the magnitude of recent meta-analyses, which have synthesized data from approximately 117 studies encompassing over 292,000 children globally. This significant body of research provides robust statistical power for assessing the association between ST and developmental outcomes. However, the data collection remains heavily concentrated geographically, primarily stemming from the United States, Canada, and Australia. This concentration limits the generalizability of findings, prompting calls for future research to incorporate more diverse, global sampling.

Table 3: Simulated Summary of Key Included Studies Linking Screen Time to Cognitive Outcomes

Study Type/Focus	Population Age Range (Years)	Primary Screen Exposure	Cognitive Outcome Measured	Key Finding (Effect Direction)	Source Reference
Longitudinal Cohort	2–3	Total Screen Time	Executive Function (EF) Development	Negative association (ST at age 2 predicts poorer EF at age 3).	

Cross-Sectional Analysis	1–3	Total Screen Time	Working Memory	Higher ST associated with lower odds of better Working Memory (WM) (OR=0.52).
Longitudinal/Neuroscience	2–3	Total Screen Time	Language Outcomes, Pars Triangularis Volume	Smaller brain volume/Weaker language skills predicted greater later ST (Bidirectional/Negative).
Systematic Review	0–6.5	Passive vs. Active ST	Attention, Language Acquisition, EF	Passive ST negatively impacts attention; Active/Educational content can positively influence development.

Impact on Executive Function (EF) and Attention

High total screen time is consistently linked to poorer outcomes in core Executive Function components, indicating a vulnerability in these higher-order cognitive skills during early childhood.

Working Memory and Longitudinal Deficits

A meta-analysis synthesizing data from toddlers (ages 1–3) found that high total screen time was associated with lower odds of having better working memory. Conversely, adherence to pediatric screen time recommendations was associated with significantly higher odds of better working memory (OR=3.48; 95% CI: 1.06, 11.47). These findings emphasize that adherence to duration guidelines is protective for specific EF skills.

Furthermore, longitudinal studies tracking children from age 2 to 3 years revealed a negative predictive relationship: screen time at age 2 was negatively associated with the subsequent *development* of executive functions at age 3, even when controlling for baseline verbal ability and other covariates. This longitudinal evidence strengthens the claim that exposure during this critical period alters developmental trajectories, rather than merely reflecting concurrent ability.

Attentional Impairment from Passive Content

Prolonged viewing of passive media, such as television or DVDs, is frequently associated with adversely affected attention maintenance and short-term memory. This effect is theorized to stem from the specific characteristics of the

media. The rapid changes in images and auditory stimuli common in passive screen activities tend to impede children's natural sensory processing capabilities. The developing brain, conditioned to respond to high-speed external inputs, may struggle to cultivate the self-directed, sustained attention necessary for complex, real-world EF tasks like inhibition and sustained focus.

Impact on Language Acquisition and Vocabulary

The data regarding screen time and language acquisition are nuanced, requiring a distinction between the type of language outcome measured and the context of use.

Negative Impact of Passive Viewing

Passive screen exposure generally correlates negatively with overall language development, impacting receptive language processing, vocabulary range, and the attention required for effective language acquisition. However, some studies have reported a lack of association between total screen time and *expressive* vocabulary. This apparent dissociation may reflect the nature of language milestones in early life; expressive language (speech production) constitutes a relatively small vocabulary in emission compared to the child's broader comprehension faculties (receptive language). The core disruption appears to be in the processing and foundational attention capacity that supports comprehension.

Parental Interaction as a Mediator

The detrimental effects of screen media on

language acquisition are often mediated by the displacement of parent-child interaction. High levels of parent-child conversation and interaction—the primary drivers of language development—are positively associated with better cognitive and socio-emotional abilities, regardless of some screen exposure. The context

of use, particularly co-viewing, is crucial in determining linguistic impact.

Differential Effects of Active Versus Passive Screen Time

The distinction between engagement types provides crucial insights into how media affects development.

Table 2: Comparative Impact of Active vs. Passive Screen Time on Cognitive Outcomes

Screen Time Type	Engagement Type	Observed Cognitive Outcome	Primary Mechanistic Explanation	Supporting Source Types
Passive Viewing	Receptive, low interaction (e.g., unsupervised TV, background noise)	Negative impact on attention, working memory, language processing, and general cognition.	Cognitive Load Overload (rapid image transitions), Displacement of interaction/play, Sensory Impedance	Cross-sectional, Longitudinal
Active/Interactive	Responsive, high interaction (e.g., educational apps, co-viewing)	Positive or neutral effects on vocabulary, visuomotor coordination, and specific EF skills.	Encourages learning, facilitates parent-child mediation, can increase alertness to stimuli	Intervention, Longitudinal
Excessive/Multi-tasking	High volume (>4 hours daily), dual input	Associated with lower scores on general cognition and poorer executive functioning.	Displacement of necessary activities (sleep, physical play), chronic cognitive overload	Cross-sectional, Meta-analysis

Active media use, especially educational and interactive content, can positively influence both vocabulary and executive function skills. Studies have shown that computer use may increase attention skills, visuomotor coordination, and sensory alertness in certain contexts. Conversely, excessive time spent in front of any screen (>5 hours per day in mothers translating to high child media use) and, critically, multitasking with media have been consistently linked to worse executive functioning and lower scores on general cognition. The quality of consumption—whether it encourages reflective processing and shared interaction—is paramount over simple duration.

Mechanisms and Developmental Implications

The adverse effects of screen time are largely attributed to two primary theoretical models: the Displacement Hypothesis and the Cognitive Load/Attentional Impairment model. Furthermore, recent longitudinal data highlights the role of bidirectional causality in amplifying developmental vulnerabilities.

Displacement Hypothesis and Opportunity Cost

The Displacement Theory suggests that the time allocated to one activity necessarily displaces time spent on others. In the context of early childhood, excessive screen exposure displaces developmentally appropriate and crucial activities, such as reading, playing, conversing with caregivers, and family interaction. These real-world, interactive engagements are essential for fostering symbolic play, problem-solving, and socio-emotional growth.

This displacement results in an environment of impoverished stimulation compared to the rich, three-dimensional feedback provided by real-time interaction. This is particularly damaging to early brain development that underpins complex cognitive skills. An indirect, but highly significant, displacement effect is the association between extended screen time and shorter sleep duration. Given sleep’s critical function in memory consolidation and neurological maturation, disruption here poses a substantial risk to cognitive health.

Cognitive Load and Attentional Impairment Models

The Cognitive Load Theory posits that the human brain operates with a limited processing capacity. Screen time, particularly passive viewing characterized by rapid transitions, visual intensity, and auditory input, can overwhelm a young child's finite cognitive resources.

This persistent, rapid-fire sensory bombardment impedes children's natural sensory processing and their ability to regulate attention. The consequence is not merely distraction, but a structural difficulty in maintaining internal focus or shifting attention, leading directly to the observed deficits in sustained attention and executive functions. This mechanism explains why passive consumption is consistently more damaging to foundational cognitive domains than active, slow-paced, or educational content.

Evidence of Bidirectional Causality and Vulnerability Amplification

A critical finding from longitudinal investigations challenges the simple interpretation that screen time solely causes deficits. Instead, evidence supports a complex, bidirectional relationship where early vulnerabilities may predispose children to increased screen use, creating a negative feedback loop.

For example, neuroscientific studies utilizing structural equation modeling have found a negative relationship between screen time and the volume of the pars triangularis (a brain region associated with language processing) at age 2. Importantly, these smaller structural volumes and weaker measured language skills at age 2 predicted greater screen time usage at age 3.

This demonstrates that children who already possess weaker language networks or struggle with complex cognitive tasks are more likely to gravitate toward screens at a later age.

When a child struggles with self-regulation, attention, or complex social interactions (often manifesting as socioemotional problems like anxiety or hyperactivity), they may turn to the easily consumable and highly structured input of passive screen media as a coping mechanism or distraction. This increased reliance subsequently exacerbates the initial deficits by consuming time that should be spent on developmentally enriching activities, such as interaction and play. Thus, early cognitive vulnerabilities are amplified by later screen reliance, underlining the sensitivity of language and EF networks to environmental input.

Discussion and Clinical Implications

Synthesis of Primary Evidence

The systematic synthesis of current evidence provides a clear consensus: excessive and unsupervised passive screen time constitutes a risk factor for diminished cognitive function in early childhood, primarily affecting Executive Function (working memory, attention) and foundational language processing. Crucially, the outcome is determined not merely by the number of hours consumed but by the quality of the

content and the context in which it is viewed. Contextual factors, such as parental mediation and co-viewing, serve as powerful protective buffers, transforming the screen interaction into a potential learning opportunity.

Furthermore, the review highlights the interdependency of developmental domains. The negative association between screen time and socioemotional problems (such as aggression and anxiety) demonstrates that the attention and self-regulation deficits resulting from poor screen habits spill over into behavioral and social difficulties.

Limitations of Current Evidence and Knowledge Gaps

While the evidence base is growing, several methodological limitations constrain the generalizability and interpretation of findings.

Measurement and Variability

A significant constraint is the high heterogeneity in study design, population sampling, and the measurement of exposure and outcome variables. Many studies rely on non-standardized parent-reported total screen time, failing to adequately differentiate between the "active" and "passive" types of use that mechanistic models have identified as key determinants of effect. This variability in measurement substantially contributes to the seemingly conflicting results found in the literature.

Geographic Bias

Research efforts are heavily concentrated in high-income, Western nations (United States, Canada, Australia). This limited global representation restricts the ability to generalize findings across diverse cultural and socioeconomic contexts, where access to media, parental guidance styles, and expectations for independent play may vary substantially.

Causal Isolation

Though longitudinal data provides valuable temporal precedence, fully isolating the causal relationship remains challenging due to the difficulty in accounting for significant confounding variables, such as household income, parental mental health, and genetic predispositions for cognitive development.

Recommendations for Future Research

To strengthen the evidence base and guide future clinical practice, research efforts should prioritize the following areas:

Standardization of Exposure Metrics: Future studies must move beyond aggregate "total screen time" measures and adopt robust, standardized, and objective measures that precisely classify screen use by type, interactivity, content, and context (e.g., degree of co-viewing).

Neurodevelopmental Pathways: Continued investigation using advanced neuroimaging techniques is crucial to map the specific

structural and functional neural pathways affected by different media types. This will help define the sensitive periods during early childhood when intervention is most effective.

Intervention Studies: The strongest evidence will come from rigorous intervention studies designed to test the mechanisms proposed by the Displacement Hypothesis. Specifically, these studies should assess whether replacing passive screen time with high-quality, parent-mediated interactive learning or real-world social play directly leads to measurable improvements in EF and language outcomes.

Conclusions and Recommendations

The systematic review affirms that screen time is a major environmental factor influencing cognitive development in early childhood. The weight of evidence suggests that potential developmental harm is primarily linked to excessive duration and passive consumption, which operate through mechanisms of displacing necessary developmental activities (play, conversation, sleep) and overloading cognitive resources. The critical modulators of this relationship are content quality and the presence of parent-child mediation.

Based on this synthesis, it is recommended that pediatric and public health guidelines maintain a strong emphasis on limiting total screen duration, especially for children under 3 years, but pivot toward prioritizing the *quality* and *context* of media use. The core recommendation remains the encouragement of co-viewing and interaction, ensuring that screen media acts as a supplement to, rather than a displacement of, crucial real-world and social learning experiences.

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