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Review Article

Screen Media Exposure in Early Childhood and Its Relation to Children's Self-Regulation

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Self-regulation, the ability to control thoughts, emotions, and behavior for goal-directed activities, shows rapid development in infancy, toddlerhood, and preschool periods. Early self-regulatory skills predict later academic achievement and socioemotional adjustment. An increasing number of studies suggest that screen media use may have negative effects on children's developing self-regulatory skills. In this systematic review, we summarized and integrated the findings of the studies investigating the relationship between young children's screen media use and their self-regulation. We searched the ERIC, PsycINFO, PubMed, and Web of Science databases and identified 39 relevant articles with 45 studies. We found that screen time in infancy is negatively associated with self-regulation, but findings were more inconsistent for later ages suggesting that screen time does not adequately capture the extent of children's screen media use. The findings further indicated that background TV is negatively related to children's self-regulation, and watching fantastical content seems to have immediate negative effects on children's self-regulatory skills. We suggest that future studies should take the content and context of children's screen media use into account and also focus on parent- and home-related factors such as parental behaviors that foster the development of self-regulatory skills.

1. Introduction

Self-regulation is a multidimensional construct that represents an individual's ability to manage thoughts, feelings, and actions to support goal-directed behavior across changing contexts [1]. Children's self-regulation skills predict their cognitive and social outcomes such as school readiness, academic achievement, and socioemotional adjustment [2–5]. Studies in recent years suggest that self-regulation is related to children's use of screen media. On the one hand, there are studies suggesting that a high dose of regular exposure to screen media is related to poorer self-regulation skills in children [6]. On the other hand, there are findings indicating that children who are rated by their parents as having poor self-regulation skills are allowed to use screen media more often [7]. Considering that children are frequently exposed to screens from an early age onwards [8–13] and the predictive role of early self-regulation for later outcomes, it is important to understand how children's self-regulation relates to their screen media use. The purpose of this review article is to provide an overview of this relationship by focusing on the age period until six, the prime years for the development of self-regulation [2, 14].

1.1. Defining Self-Regulation. Self-regulation has been investigated by researchers across different fields of study, leading to a lack of consistency in its definition and measurement and a lack of conceptual integration across disciplines [1, 15–20]. Jones et al. [21] identified over 40 unique terms in the literature that define regulation-related skills; however, researchers agree that the two terms that stand out in the self-regulation literature are executive functions and effortful control [22–25].

Executive functions are mostly studied from a cognitive perspective and are characterized as top-down processes that help individuals engage in goal-directed behaviors and control and regulate automatic processes and prepotent responses [26]. Executive functions have been conceptualized as a unitary construct [27] or a unitary construct with dissociable components like working memory (for storing and manipulating information in mind), inhibitory control (for inhibiting prepotent responses and behaviors), and cognitive flexibility (for flexibly adjusting to new demands and changing perspectives) [28, 29]. Executive functions are usually measured with standardized lab-based tasks that assess separate components (e.g., backward digit span task to measure working memory) or a combination of these (e.g., Tower of Hanoi task to measure planning). Children's early executive functions predict later school readiness and academic achievement [30–32]. Parental behaviors (scaffolding, autonomy support, and controlling), attachment security, and socioeconomic status and risk are associated with children's executive functions [33–37].

In contrast to executive functions, effortful control has mostly been studied from a socioemotional perspective and is thought to be a critical component of emotion regulation [38]. Effortful control is the temperamental dimension that corresponds to individual differences in the ability to regulate emotions and actions [39–41]. Skills like inhibitory control, voluntary control of attention, conflict resolution, error detection and correction, and planning are thought to be part of this construct [42]. Effortful control is typically measured via parent or teacher reports (e.g., Child Behavior Questionnaire by [43]), but laboratory tasks to measure inhibitory skills and direct observations of behavior in naturalistic settings are used as well [44]. Children's effortful control is positively associated with prosocial behavior and social competence and negatively associated with internalizing and externalizing problems [45, 46]. Demographic and psychosocial risk, along with parental responsiveness and parental positive and negative control behaviors, is associated with children's effortful control [47–49].

Researchers have proposed a unifying framework for self-regulatory skills that combines the two different works of literature of executive functions and effortful control. Zhou et al. [25] proposed an integrated model of self-regulation encompassing both of these constructs based on their commonalities (e.g., inhibitory control) and correlations between behavioral tasks measuring executive functions and parent and teacher reports measuring effortful control [31, 50]. More recently, Nigg [20] emphasized the need to integrate executive functions and effortful control, and Bailey and Jones [22] argued that a unifying framework would provide a more comprehensive account of regulatory skills. Here, we employ such a unifying framework for self-regulatory skills and focus on the studies investigating the relationship between young children's screen media use and self-regulation.

1.2. Understanding How Screen Media Use Relates to Self-Regulation. There are several nonmutually exclusive hypotheses about how children's cognitive and social abilities—including self-regulation—may be associated with their use of screen media [51]. One explanation is that the quality time that could be spent alone or with caregivers on enriching and educational activities is displaced with screen time that provides fewer opportunities for cognitive and social growth [52–54]. Given the strong links between children's self-regulatory skills and parental behaviors like sensitivity and scaffolding [34, 49, 55], it is plausible that self-regulation shows a less than optimal development when the frequency and quality of parent-child interactions suffer due to excessive screen media use by children.

Another hypothesis linking children's self-regulation to their screen media use suggests that compared to screen media, other activities such as schoolwork may seem less exciting and less interesting for children as screen media often contains fast-changing scenes and attention-grabbing properties [51]. In a similar vein, Singer [56] proposed that children's attention to TV is maintained via perceptually salient auditory and visual changes, and thus, regular exposure to TV may lead children to rely on the environment rather than on internal goals and motivations to maintain focused attention. As self-regulation requires top-down control of emotions, thoughts, and actions and is linked to the ability to control attention [57–59], the bottom-up effects of screen media on attention may be disruptive for the development of self-regulatory skills. Thus, the first question that this review aims to answer is whether children's screen time is negatively associated with their self-regulatory skills. But all screen time is not equal. Children can spend time on *traditional* vs. *interactive* media, where the former corresponds to TV watching and the latter encompasses activities such as playing video games, video chatting, and watching videos. When spending time on interactive devices, children may be more likely to engage in goal-directed activities that necessitate the use of regulation-related functions. Therefore, a related question we aim to answer is whether the association between screen time and self-regulation differs for traditional and interactive media.

Whether screen time has adverse effects on child development is particularly debated for infants. World Health Organization (WHO) [60] and the American Academy of Pediatrics [61] recommend no screen time for infants younger than age two with the exception of video chatting, but research shows that infants are exposed to screens starting from a young age [8, 10, 62]. An early exposure to TV and TV viewing in infancy are associated with negative developmental outcomes in terms of attention and language [63]. Any negative effects of screen exposure in infancy may be related to the fact that infants learn best through social interactions and fail to acquire new knowledge from screen media, including infant-directed DVDs and YouTube videos [64–68]. Thus, another aim of this review is to examine whether screen exposure in infancy is detrimental to the development of self-regulation.

Despite many findings showing negative associations between screen time and child outcomes, there are also studies reporting no associations or positive relations [69]. Inconsistent findings may point to problems in measuring children's screen time as well as to the importance of other

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aspects of screen media use such as content (e.g., educational vs. entertainment) and context (e.g., parental mediation of child media use) [63, 69, 70]. The content children consume on screens shows variation as some shows/applications are only entertainment-oriented, whereas others contain both education- and entertainment-related elements; some are more realistic, and others tend to be more fantastical. Hence, another aim of this review is to reveal the relations between children's self-regulation and the content they consume on screens.

Apart from the content, contextual factors such as parent-child interactions during screen media use and the use of screen media during different family routines such as bedtime and meals may be important. One such contextual factor is whether children use screen media as a primary or secondary activity. While children are involved in a primary activity such as individual play and play with their parents, they are often exposed to the television running in the background [71–74]. Background TV negatively affects caregiver-child interactions, children's play behaviors, and focused attention [75–77]. Given that the development of self-regulation is related to both caregiver-child interactions and children's attentional control skills, background TV may have detrimental effects on children's self-regulation. Thus, another goal of this review is to summarize the findings pertaining to the relationship between background TV and self-regulation.

Finally, another contextual factor that may be important is parent-related factors such as parental restrictions on children's screen media use. A recent study with a large sample size (>10,000) of US elementary school children reported that children had a lower risk of later frequent use of online technologies if families had certain rules on children's TV use such as when and what to watch [78]. Hence, a question to be answered is whether parental practices in terms of regulating children's screen media use have a protective role against the potentially negative effects of screen media. Furthermore, any negative effects that screen media use might have on children's self-regulation may be alleviated by positive parental behaviors such as parental responsiveness and scaffolding that support the development of self-regulatory skills. Thus, the final goal of this review is to examine the role of moderating and protective parent-related factors.

2. Current Review

To date, no systematic review article has comprehensively integrated the findings of studies that investigate the relations between young children's screen media use and self-regulation. Some of the previous review articles focused only on one aspect of self-regulatory skills such as executive functions or one aspect of screen media use such as TV viewing [63, 79]. Other review articles were either not systematic [80] or omitted relevant articles by using a limited or highly specialized (e.g., health-related) pool of databases [79, 81]. Thus, the current study is aimed at providing a systematic review of young children's (age < 6) screen media consumption and their self-regulation by conducting a thorough database search and identifying the current gaps in the literature. The questions that this review aims to answer revolve around three main topics, namely, the relation of children's self-regulation to (1) screen time, (2) screen media content, and (3) screen media context. To reiterate, our research questions regarding each of these three dimensions are as follows:

(1) Is there a negative association between children's screen time and self-regulation?
   (a) Does this relationship differ for traditional and interactive media?
   (b) Is screen time in infancy particularly detrimental to self-regulatory skills?

(2) Is there a relationship between children's self-regulation and the content they are exposed to on screens?

(3) Are contextual factors related to children's screen media use relevant to children's self-regulation?
   (a) Is background TV negatively associated with children's self-regulation?
   (b) Are there any moderating variables like parenting behaviors or parental rules regarding screen media use that may influence the relationship between children's self-regulation and screen media use?

3. Method

The current review followed the guidelines of the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement for reporting the search strategy and eligibility criteria [82].

3.1. Search Strategy. Using the ((“*self-regulation*” *OR* “*executive function* *” *OR* “*effortful control*”) *AND* (“*media exposure*” *OR* “*mobile device*” *OR smartphone OR tablet OR technology OR TV OR* “*digital media*” *OR computer OR* “*screen media*” *OR* “*screen time*”) *AND (infant* *OR child *)) keywords, we searched the ERIC, PsycINFO, PubMed, and Web of Science databases in March 2021. Bibliographies of the relevant articles were further hand searched.

3.2. Inclusion and Exclusion Criteria. We used the following eligibility criteria for the studies to be included in this review: studies had to have an assessment of children's self-regulation and an assessment or manipulation of screen media use. Studies had to have children younger than age six and/or their parents as participants. For longitudinal studies, children had to be younger than age six at the first measurement point. Studies had to be published in peer-reviewed journals and written in English to establish a form of quality check. Unpublished dissertations and conference proceedings were excluded to ensure that the selected articles had undergone rigorous peer review. There was no limitation

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regarding the publication date of the studies. The first author removed the duplicates, and all authors independently screened the articles based on titles and abstracts. Discrepancies were resolved by discussion. The full texts of the remaining articles were screened for eligibility by the first author by using the criteria listed above. Figure 1 shows the search and elimination process of the articles.

3.3. Data Extraction. For each article, the following information was extracted: (1) type of the study (correlational vs. experimental), (2) design of the study (cross-sectional vs. longitudinal), (3) sample size, (4) age range of participants, (5) information related to the socioeconomic status of the participants, (6) country where the study took place, (7) how children's self-regulation was measured, (8) how children's screen media use was measured or how the screen content/use was manipulated (for experimental studies), (9) control variables/covariates, and (10) main findings. The second and third authors entered information about each study into a summary table, and the first author verified this information (see Table 1). If the studies included effect sizes, these values are reported in Table 1.

3.4. Quality Assessment. We assessed the quality of each study by using the Downs and Black checklist [83], which comprises 27 items. All of the items were not relevant to each type of study design; therefore, similar to Faelens et al. [84], we used 11 items for the coding of cross-sectional correlational studies, 14 items for longitudinal correlational studies, 21 items for experimental studies, and 24 items for longitudinal experimental studies with a maximum score of 11, 14, 22, and 25, respectively. The relevant items for different types of study design are provided as supplementary materials (available here). Three articles that were included in the review had multiple studies resulting in 45 studies to be coded. The second and third authors each coded 18 studies independently. Interrater reliability computed with Cohen's kappa based on the nine studies coded by the second and third authors was 0.94, indicating almost perfect agreement. Disagreements were resolved by discussion.

4. Results

4.1. Overview. As shown in Figure 1, 3,987 articles were identified through database search (ERIC: 106, PsycINFO: 1,340, PubMed: 895, and Web of Science: 1,646), and seven additional articles were identified through backward citation search. After the removal of the duplicates and the elimination process based on titles and abstracts, 60 articles remained. Out of these 60 articles, 39 articles (having 45 independent studies) matched the inclusion criteria and were included in this review. Except for two studies published in 1973 and 1979, all studies were published between 2010 and 2020. Here, we will first summarize the findings of the studies that investigated the relations between children's screen time and self-regulation by focusing on the studies testing concurrent and predictive relations in order. In the same section, we will summarize the findings pertaining to the time spent with traditional vs. interactive media and screen exposure in infancy. Then, we will review the findings of how screen media content and context (e.g., background TV and parent-related factors) relate to children's self-regulatory skills (see Table 2 for a categorization of studies according to different themes).

4.2. Screen Time

4.2.1. Concurrent Relations between Screen Time and Self-Regulation. Seven studies examining the relationship between children's self-regulation and the time spent with traditional media found children's TV viewing amount to be associated with poorer self-regulatory skills (e.g., poorer executive functioning and more self-regulatory problems) [6, 85–90]. In contrast to these findings, two studies reported nonsignificant relations [91, 92], and one reported a positive association between TV viewing and executive functions [93] where the sample had a relatively low amount of TV viewing (M (SD) = 1.22 (0.93) hours) compared to the samples in other studies.

The examination of the relationship between children's self-regulation and interactive media use similarly produced inconsistent findings. Three studies did not report significant relations between interactive media use and executive functions and self-control [86, 91, 92]. In contrast, a positive relation was reported by Yang et al. [94]; however, the unique variance in executive functions that was explained due to the time spent playing electronic games was relatively low (0.001). In other work, sleep was shown to be a moderator where children's effortful control was negatively related to tablet use if they received less sleep but positively related to game player use if children slept more [95]. Yet, the regression coefficients of these screen time predictors were relatively small (β's = 0.0007 and 0.0009). Overall, current evidence does not seem to suggest any strong relations between interactive media use and children's self-regulatory skills.

In contrast to the studies that differentiated between traditional and interactive media, several studies used a measure of total screen media use spanning both the time spent watching and interacting with screen media devices. Four out of these five studies reported negative relations between self-regulation and screen time or a lack of compliance with screen time recommendations [96–99], and one study reported null findings [100].

In sum, the majority of the findings indicate a negative relation between TV viewing and children's self-regulatory skills; however, it cannot be concluded that TV viewing is detrimental to the development of self-regulatory skills since some studies reported no significant relations between these variables.. Regarding the use of interactive media, null findings and small effect sizes indicate that it may not be strongly related to self-regulation.

4.2.2. Predictive Relations between Screen Time and Self-Regulation. While most of the studies investigated concurrent relations between children's screen time and self-regulatory skills, longitudinal studies focusing on early screen time's predictive capacity for later self-regulation

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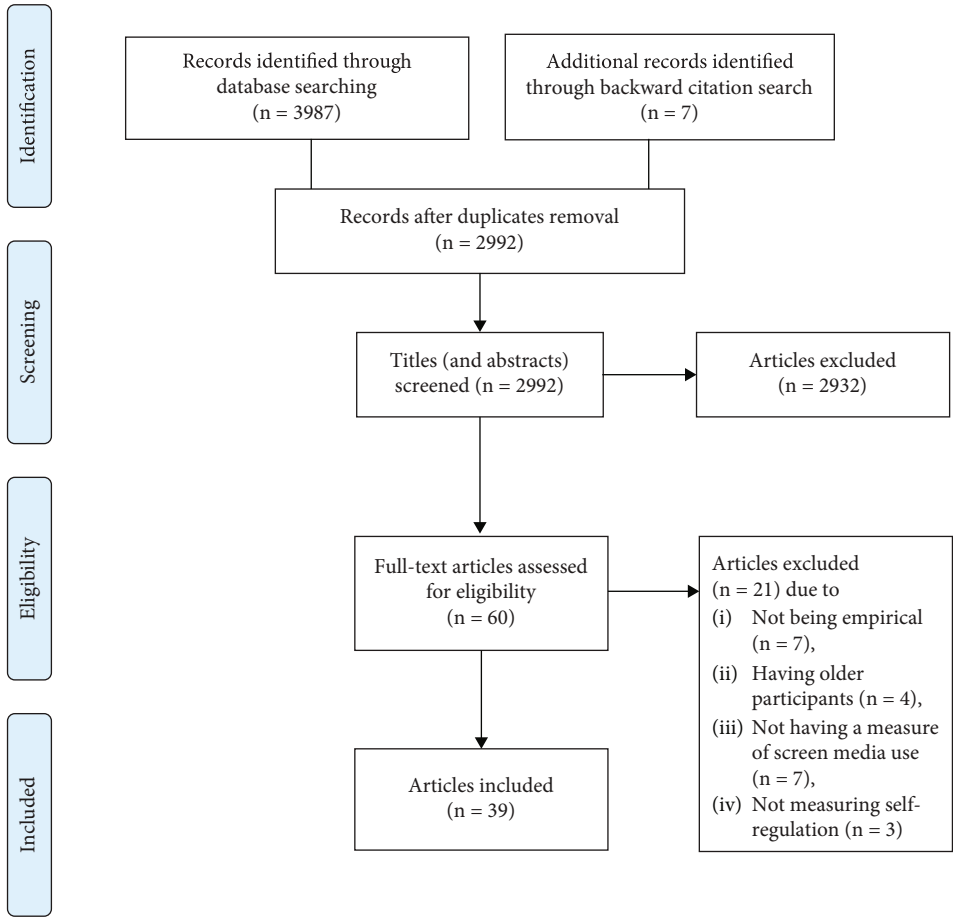


Figure 1: PRISMA flow diagram.

have been conducted as well. Studies assessing screen time in infancy (age ≤ 2) reported that early screen exposure was negatively related to later self-regulatory skills [7, 69, 100, 101]. For preschool-aged children, findings were more inconsistent as some studies reported that higher screen time predicted poorer self-regulation ([88, 102, 103] for application use) and others reported null findings ([104] (after including parent- and home-related control variables); [7, 103] (for program viewing); [105]). Regarding the traditional versus interactive media distinction, longitudinal studies did not provide sufficient evidence as only three studies measured these separately [7, 103, 105]. Except for McNeill et al. [103] that demonstrated a negative association between early application use and later executive functions, other studies found nonsignificant relationships between interactive media use and self-regulation.

Longitudinal studies mostly focused on the predictive role of early screen media exposure for later self-regulation, but there were some studies examining whether early self-regulatory skills may predict later screen media use. Relatedly, it has been demonstrated that infants with longer crying durations and children with more difficult temperaments (such as children with higher irritability and distractibility) are allowed to have longer screen time [106–108]. In a similar vein, two studies reported that early self-regulatory skills were negatively associated with later screen time [7, 109], but not all studies supported this claim [100].

Overall, similar to cross-sectional studies, longitudinal research reported mixed findings in terms of the relationship between screen time and self-regulatory skills. These mixed findings were especially evident for preschool-aged children.

4.2.3. Screen Time in Infancy. Studies were in consensus that screen time in infancy is negatively related to children's self-regulatory skills. To summarize, early (age ≤ 2) screen exposure was found to be positively associated with self-regulatory problems [97] and negatively associated with later executive functions [100, 101] and self-regulatory skills measured via parent, teacher, and observer reports [7]. To complement these findings, an earlier onset age of screen viewing was found to be negatively associated with executive functions [6]. Overall, these findings suggest that early screen exposure might be detrimental to children's developing self-regulatory skills. It must also be noted that the effects of early exposure may depend on the screen media content since Barr et al. [110] reported that early exposure to adult-directed but not child-directed TV was negatively associated with later executive functions.

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Table 1: Summary of included studies.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[85]	Cross-sectional correlational	A representative sample of 10,995 3-year-olds in the UK	Child's age, sex, birth weight, ethnicity, household income, country, parental age and education	Child Social Behavior Questionnaire which is adapted from the Adaptive Social Behavior Inventory (parental report)	Amount of TV/video viewing (none, <1 hour, 1-3 hours, and >3 hours per day) (parent estimate)	Higher amounts of TV/video watching predicted more emotional self-regulation problems ($\beta = 0.12$, $p < 0.001$). Children who watched TV/videos more than 1 hour per day were more likely to be in the lowest emotional self-regulation quartile compared to children who watched TV/videos less than 1 hour per day (OR = 0.73, $p = 0.002$)	11/11
[114]	Experimental	78 American children aged between 29 and 35 months; 64% from middle-class backgrounds	None (groups did not differ on temperament, language exposure, experience with playing games on a touchscreen, and TV exposure)	Sorting task (cognitive flexibility) and statue task (inhibitory control)	Children assigned to touchscreen play, physical play, or drawing (control) conditions (for 9 minutes)	Cognitive flexibility scores were higher in the physical play compared to the touchscreen play condition ($t(46.76) = 2.48$, $p = 0.017$, $d = 0.69$) and the control condition ($t(45.72) = 2.16$, $p = 0.036$, $d = 0.60$) Children who did not frequently initiate social interaction during touchscreen play performed worse in the sorting task compared to children in the physical play condition ($t(17.98) = 2.96$, $p = 0.008$, $d = 1.07$). Children who frequently initiated social interactions during touchscreen play performed similarly to the physical play group in the sorting task. There was no difference across groups in terms of inhibitory control	17/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[110]	Longitudinal correlational	60 American children aged between 12 and 18 months at time 1 and aged 4 at time 2; parents were mostly middle class with high education	None (no relation of EF to child sex, ethnicity, or SES)	The Behavior Rating Inventory of Executive Functioning-Preschool Version (parental report), Shape school task (switching and inhibition)	TV viewing amount and content (parent-reported 24-hour time diary)	Adult-directed TV exposure in infancy predicted lower parental ratings of children's global EF ($t(51) = -2.16$, $p = 0.04$). There was a significant main effect of adult-directed exposure during infancy on the Inhibitory Self-Control Index ($F(1, 51) = 4.41$, $p = 0.04$, $\eta_p^2 = 0.08$). Higher amount of household TV at age 4 was associated with poorer parental ratings of children's global EF ($t(53) = -2.98, p < 0.01$). There was a significant main effect of total household television during preschool on the Inhibitory Self-Control Index ($F(1, 53) = 4.80$, $p = 0.03$, $\eta_p^2 = 0.08$). Controlling for parental education, high levels of adult-directed TV exposure at age 4 were related to worse performance on Shape school task ($F(1, 43) = 4.18$, $p = 0.05$, $\eta_p^2 = 0.10$). At both ages, child-directed TV exposure was not related to EFs	10/14
[104]	Longitudinal correlational	228 American children aged 3 at time 1, 4 at time 2, and 5 at time 3; 51% of mothers had a college degree	Family SES, child race, parental scaffolding, and home learning environment	Animal Stroop task (inhibitory control), Kaufman assessment battery for children number recall test (working memory)	TV viewing amount (parent estimate)	TV viewing at age 3 ($r = -0.19$, $p < 0.01$) and at age 4 ($r = -0.13$, $p < 0.05$) was negatively correlated with composite EF score at age 5, but these relations became nonsignificant after controlling for covariates	11/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[91]	Cross-sectional correlational	100 Canadian children aged 30 to 59 months; 70% of parents had at least a bachelor's degree	None	Nebraska Barnyard task (working memory), Fish-Shark Go/No-Go task (inhibitory control)	TV, computer, and video game playing amount (parent estimate)	No significant association between the amount of time children spent viewing TV, playing video games, and working memory and response inhibition	8/11
[7]	Longitudinal correlational	2786 Australian children at 2 years and 3527 children at 4 and 6 years of age; parents were mostly from middle to upper-middle class	Child's age and sex, SES, and parenting hostility	A composite measure of self-regulation from a caregiver, teacher, and observer report	TV, computer, and electronic game playing amount (parent estimate)	Lower total screen media exposure ($\beta = -0.05$; 95% CI: -0.08 to -0.01) and TV viewing ($\beta = -0.05$; 95% CI: -0.08 to -0.01) at age 2 predicted higher self-regulation at age 4, but not age 6. Lower self-regulation at age 4 predicted higher TV viewing ($\beta = -0.07$; 95% CI: -0.10 to -0.04), electronic game use ($\beta = -0.04$; 95% CI: -0.08 to -0.01), and total media exposure ($\beta = -0.06$; 95% CI: -0.09 to -0.03) at age 6. Screen media use at the age of 4 did not predict self-regulation at age 6	10/14
[96]	Cross-sectional correlational	42 Brazilian low-SES children aged between 3 and 5; 51% of the parents were unemployed; most mothers (72%) did not complete high school	None	Early Years Toolbox, Go/No-Go task (accuracy of No Go trials for inhibitory control)	Amount of use of TV, computer, smartphones, and electronics games (parent estimate) Children were classified as compliant with screen time recommendations of the World Health Organization if they had (a) ≤1 h/day screen time for 3- and 4-years-olds or (b) ≤2 h/day screen time for the 5 years-olds	A network analysis showed that compliance with the screen time recommendation was negatively associated with No Go accuracy (-0.26)	5/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[123]	Experimental	141 low-SES American children aged 2 to 5 enrolled in Head Start programs	Baseline self-regulation scores	Task persistence and participation in classroom routines such as circle time and cleanup time observed by researchers in classroom settings for 12 weeks in the baseline and 8 weeks in the experimental period	Children assigned to one of four intervention programs which include watching neutral content, prosocial content, prosocial content with related materials, and prosocial content with related materials and teacher instruction for 8 weeks (media exposure lasted for 14-20 minutes in each session)	Children's pre- and post-self-regulation scores did not differ significantly among conditions	16/25
[122]	Experimental	97 American children aged between 3.8 and 5.5; on average, parents had some university education	None	Rule obedience, tolerance of delay, and task persistence observed by researchers in school settings for 3 weeks in the baseline, 4 weeks in the experimental, and 2 weeks in the postviewing period	Children exposed to aggressive (for 20 minutes), prosocial (for 28 minutes), or neutral (for 10-15 minutes) content for 4 weeks	Tolerance of delay decreased from pre- to posttest in the aggressive condition and increased in other conditions ($F(2, 80) = 3.66$, $p < 0.05$. Task persistence and rule obedience did not significantly change	17/25
[102]	Longitudinal correlational	1644 Canadian children aged 3 at time 1 and aged 5 at time 2; 76% of mothers had partial or complete university/college or trade degree, and 33% of household income was 150,000 or above	Household income, maternal mental health (maternal depression and anxiety), child age and sex, maternal age, child care (spending more than 10 hours a week outside the home in child care), and positive and negative parenting styles measured by National Longitudinal Study of Children and Youth	Behavior Assessment System for Children (for the three elements of self-regulation including inattention, emotional control, and behavioral control) (parent estimate)	Amount of TV/movie viewing and video game playing (parent estimate)	Excess screen time (>1 h per day) at age 3 was related to poor self-regulation at age 5. One additional hour of screen time per day was associated with a 1.23 increased odds of any element of poor self-regulation (95% CI: 1.03-1.47) and a 1.42 increased odds of inattention (95% CI: 1.13-1.79)	10/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[87]	Cross-sectional correlational	558 Chinese preschoolers (mean age: 6.12) from different socioeconomic backgrounds (advanced, average, and below average)	Family SES, child's age and gender, and TV/computer in child's bedroom	Head-Toes-Knees-Shoulders task (rule switching and inhibition), Social Skills Improvement System-Rating Scales (parental report of social skills including self-control)	TV and computer use amount and content (parent estimate)	Children's TV viewing time ($B = -0.09$, $p = 0.046$) and the frequency of watching nonkid shows on the computer ($B = -0.09$, $p = 0.049$) were negatively associated with their cognitive skills (note: HKTS score was taken as part of children's cognitive skills) Children's TV viewing time ($B = -0.95$, $p = 0.049$) and frequency of watching cartoons on the computer ($B = -0.97$, $p = 0.048$) were negatively related to their social skills. The frequency of TV-based educational puzzle games ($B = 1.75$, $p = 0.015$) and computer viewing time ($B = 0.93$, $p = 0.042$) was positively associated with social skills. Parental restrictions on children's TV time ($r = 0.21$, $p < 0.01$) and content ($r = 0.18$, $p < 0.01$) were positively related to children's cognitive skills. Similarly, restrictions on children's TV time ($r = 0.20$, $p < 0.01$) and content ($r = 0.28$, $p < 0.01$) were positively related to children's social skills	9/11
[86]	Cross-sectional correlational	579 Chinese 5-year-olds from different socioeconomic backgrounds (advanced, average, and below average)	Family socioeconomic status, child's age and sex	Head-Toes-Knees-Shoulders task (rule switching and inhibition), Social Skills Improvement System-Rating Scales (parental report of social development including self-control)	Passive (TV/video) and active (computers, tablets, and smartphones) screen time (parent estimate)	Passive screen time negatively predicted children's EF ($\beta = -0.16$, $p < 0.001$) and social skills ($\beta = -0.11$, $p < 0.01$), whereas active screen time was not related to EF and social skills	8/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[111]	Experimental	96 middle- to upper-middle-SES Australian children aged 24 to 48 months	Task order, age, and baseline EF	Pretest includes Spin the Pots (visuospatial working memory) and Reverse Categorization (switching and response inhibition) tasks Posttest additionally includes the Gift Delay Task (inhibitory control)	Children assigned to watching a cartoon, playing an educational app, or watching an educational program condition (for 9 minutes)	Scores in the Spin the Pots task were higher in the educational application compared to educational TV and cartoon watching conditions, but this held true only when this task was presented after the Reverse Categorization task ($F(2, 33) = 5.27$, $p = 0.01$, $\eta_p^2 = 0.24$) There were no group differences in the Reverse Categorization task. When age was controlled, children were more likely to pass the Gift Delay task in the educational application condition compared to cartoon watching condition 95% CI:1.69- 40.92 ($\chi^2(1) = 6.80$, $p = 0.009$. Other group differences were not significant for this task	18/22
[88]	Longitudinal correlational	A nationally representative sample of 32,439 Japanese children aged 3 at time 1, 4 at time 2, and 5 at time 3	Child's sex and hyperactivity, parental age, education, smoking, and employment status	Parental report of self-regulation (6-item self-regulation survey created for this study)	TV and video game playing amount (parent estimate)	Boys who watched more than 5 hours of TV at age 3 were more likely to have self-regulation problems at age 5 than boys who watched TV 1 to 2 hours per day (OR 1.77, 95% CI: 1.06-2.93). Boys who played video games for 1 hour or less at age 3 were less likely to have self-regulation problems at age 5 than boys who did not play any video games (OR 0.53, CI: 0.37-0.76). At age 4, boys who watched TV for 4-5 hours per day were more likely to have subsequent self-regulation problems than boys who watched TV for 1-2 hours per day (OR 1.79, CI: 1.22-2.64). At age 4, girls who had longer TV viewing durations were at a higher risk for later self-regulation problems (2-3 h: OR 1.40, CI: 1.03-1.90; 3-4 h: OR 1.65, CI: 1.13-2.40; 4-5 h: OR 2.59, CI: 1.59-4.22)	8/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[115]	Experimental	143 Chinese children aged between 5 and 6.5, mostly from middle-class families with most mothers having at least a bachelor's degree	SES (groups did not differ in age, language development, TV viewing amount, parental education, and pretest EF)	Pretest includes the Children Behavior Questionnaire-Short Form Posttest includes NIH Toolbox App: Flanker Inhibitory Control and Attention Test, the DCCS Task (cognitive flexibility), and the List Sorting Working Memory tasks	Children assigned to high, mid, or low amount of fantasy cartoon conditions (for 12 minutes)	Children in the low fantasy condition had the highest inhibitory control ($F(2, 135) = 18.00$, $p < 0.001$, $\eta^2 = 0.21$) and cognitive flexibility scores ($F(2, 135) = 18.12$, $p < 0.001$, $\eta^2 = 0.21$) compared to the children in other conditions. For both inhibitory control and cognitive flexibility, scores were higher in the high fantasy compared to mid-fantasy condition. There was no difference in working memory across conditions	17/22
[92]	Cross-sectional correlational	190 Lithuanian children in 4- and 5-year-olds; 77% of mothers and 60% of fathers had university-level education	Parental education, child's age	Shape school task (mental set shifting), missing scan task (working memory), and head and feet task (inhibitory control)	TV, smartphone, tablet, and computer use amount (parent estimate)	No significant association between different EF components and the use of any type of screen (note: analyses were conducted separately for different devices)	8/11
[120]	Experimental	187 children from the UK aged 42 to 62 months; 50% of children from low SES	Age, pretest EF	Both pre- and posttest include the Day/Night task (inhibitory control)	Children assigned to fast-realistic, slow-realistic, fast-unrealistic, or slow-unrealistic TV conditions (for ~5-6 minutes)	Inhibitory control scores were higher after watching unrealistic compared to realistic content ($F(1, 170) = 4.34$, $p = 0.039$, $\eta_p{}^2 = 0.03$). Pace did not have a significant effect	18/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[116]	Experimental	Study 1: 90 Chinese preschoolers between the ages 4 and 6, mostly from working- and middle-class annual household incomes	Children's hyperactivity level and age	Backward Digit Span Task (working memory), Day–Night Task (inhibitory control), and Flexible Item Selection Task (cognitive flexibility)	Children assigned to one of these three conditions: viewing a video episode with high fantasy (46 fantastical events) for 18 minutes, viewing a video episode with low fantasy (17 fantastical events) for 19 minutes, and no viewing (usual classroom activities for 18-19 minutes)	There was an immediate negative effect of watching frequent fantastical events on children's composite EF score ($F(2, 86) = 6.99$, $p < 0.005$, $\eta_p = 0.14$) Children watching video programs with a high frequency of fantastical events had lower EF than children watching video programs with a low frequency fantastical events ($t(58) = -2.56$, $p < 0.05$, $d = 0.66$) and children in the control group ($t(58) = -2.95$, $p < 0.01$, $d = 0.76$). The low fantasy and control groups did not differ	16/22
		Study 2: 20 Chinese preschoolers between the ages 4 and 6, from the same public preschool where study 1 was conducted	Children's hyperactivity level	Backward Digit Span Task (working memory), Day–Night Task (inhibitory control), and Flexible Item Selection Task (cognitive flexibility) and tracking of eye movements	High and low fantasy conditions	The high fantasy group demonstrated lower performance on the behavioral EF tasks than the low fantasy group ($t(16) = -2.51$, $p < 0.05$, $d = 0.31$) Analyses regarding eye tracking data showed that compared to the low fantasy group, the high fantasy group had more ($t(16) = -3.68$, $p < 0.005$, $d = 1.72$), but shorter ($t(16) = 4.93$, $p < 0.001$, $d = 2.29$) fixations	16/22
		Study 3: 20 Chinese preschoolers between the ages of 4 and 6, mainly from middle-class families	Children's hyperactivity level	Backward Digit Span Task (working memory), Day–Night Task (inhibitory control), and Flexible Item Selection Task (cognitive flexibility) and fNIRS technology to measure cerebral blood flow to PFC	High and low fantasy conditions	High fantasy group did more poorly on behavioral measures of EF ($t(18) = -2.51$, $p < 0.05$, $d = 0.31$) Analyses regarding fNIRS data showed that there were two epochs in which high fantasy group significantly exceeded the other in prefrontal processing ($t(19) = 2.05$, $p = 0.05$, $d = 0.94$) for the first epoch and ($t(19) = 2.32$, $p < 0.05$, $d = 1.06$) for the second epoch)	16/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
		Study 1: 72 Chinese children (36 children with a mean age of 55.9 months and 36 children with a mean age of 75.3 months), mostly from middle-class families with high education	None	Go/No-Go task (inhibitory control) in pre- and posttest	Children assigned to playing a fantastical video game or watching a video clip of the same game conditions (for 11 minutes)	In the condition where children watched a video clip of the fantastical game, inhibitory control decreased from pre- to posttest ($F(1, 68) = 6.10$, $p < 0.05$, $\eta^2 = 0.08$). There was not a significant change in the video game playing condition	13/22
[118]	Experimental	Study 2: 19 Chinese children with a mean age of 72.5 months (final sample: 17 participants)	None	Go/No-Go task (inhibitory control) and fNIRS measurement in pre- and posttest	Children assigned to playing a fantastical video game or watching a video clip of the same game conditions (for 5 minutes)	Inhibitory control decreased from pre- to posttest in the video viewing condition ($F(1, 16) = 11.81$, $p < 0.01$, $\eta_p{}^2 = 0.43$) but showed no change in the video game play condition Posttest fNIRS activation was greater compared to pretest activation in the video viewing condition (channel 11: $F(1, 16) = 4.47$, $p < 0.05$, $\eta_p{}^2 = 0.22$; channel 20: $F(1, 16) = 11.59$, $p < 0.01$, $\eta_p{}^2 = 0.42$)	16/25
		Study 3: 72 Chinese children (36 children with a mean age of 54 months and 36 children with a mean age of 76 months)	None	Go/No-Go task (inhibitory control) in pre- and posttest	Children assigned to playing a realistic video game or watching a video clip of the same game conditions (for 11 minutes)	For both conditions, children's postinhibition scores were higher than baseline scores (for accuracy: $F(1, 68) = 12.85$, $p < 0.001$, $\eta_p{}^2 = 0.16$; for reaction time: $F(1, 68) = 22.44$, $p = 0.001$, $\eta_p{}^2 = 0.30$; and for response sensitivity: $F(1, 68) = 14.85$, $p < 0.001$, $\eta_p{}^2 = 0.18$). There was not a significant difference between conditions	14/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[117]	Experimental	Study 1: 160 American 4-year-olds (48-66 months) and 6-year-olds (67-91 months), mostly from middle-class families	None (no group differences in children's screen media use amount and their scores in the Strengths and Difficulties Questionnaire)	Hot EF task: delay of gratification (inhibitory control) Cool EF tasks: Tower of Hanoi (planning), Head Toes Knees Shoulders (rule switching and inhibition), and Woodcock-Johnson III Test of Cognitive Abilities (auditory working memory)	Children assigned to fast-fantastical cartoon, slow-realistic cartoon, or playing (control) conditions (for 11 minutes)	In both age groups, children in the fast-fantastical cartoon condition had higher composite cool EF scores compared to children in the control condition ($F(3, 159) = 3.10$, $p = 0.03$, $\eta_p^2 = 0.06$) Children in the slow-realistic cartoon condition were better in the delay of gratification task compared to children in the control condition ($F(3, 146) = 3.18$, $p = 0.03$, $\eta_p^2 = 0.06$)	17/22
		Study 2: 60 children aged 47 to 67 months, mostly from middle-class families	None (groups did not differ on temperament, vocabulary, and TV exposure)	Woodcock-Johnson III Test of Cognitive Abilities (auditory working memory), Tower of Hanoi (planning), Dimensional Change Card Sort (DCCS) task (cognitive flexibility), and Luria's Hand Game (inhibitory control)	Children assigned to watching a fantastical cartoon, watching an educational cartoon, or listening to an educational picture book conditions (for 22 minutes)	Children in the educational book condition had higher composite EF scores than educational and fantastical cartoon viewing conditions ($F(2, 59) = 5.77$, $p = 0.005$, $\eta_p^2 = 0.17$)	17/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
		Study 3: 80 American children aged 47 to 60 months	Pretest EF (across groups, children did not differ on temperament and screen media exposure)	Pretests include the Executive Function Scale for Preschoolers (the scale version of the DCCS to measure cognitive flexibility), Hand Game (inhibitory control), Woodcock-Johnson III Test of Cognitive Abilities (auditory Working Memory), and Gift Wrap Delay (inhibitory control) tasks Posttests include Head Toes Knees Shoulders (rule switching and inhibition), Day/Night task (inhibitory control), Auditory Working Memory Span subtest, Forbidden Toy (inhibitory control was not included in the composite EF score), and Tower of Hanoi (planning) tasks	Children assigned to fast- and slow-paced cartoon with rare or abundant fantasy events (i.e., four conditions in total)	Children who watched fantastical cartoons had lower composite EF scores than children who watched realistic cartoons ($F(1, 79) = 6.69$, $p = 0.01$, $\eta_p{}^2 = 0.08$). Controlling for pretest working memory, posttest working memory scores were higher in the conditions with rare fantasy events and lower in the condition with abundant fantasy events ($F(1, 79) = 6.13$, $p = 0.02$, $\eta_p{}^2 = 0.08$)	17/22
[121]	Experimental	60 middle- to upper-middle-SES 4-year-olds from the USA	Children's TV/DVD viewing amount (parent estimate), the Strengths and Difficulties Questionnaire, and age	Tower of Hanoi (planning), Head Toes Knees Shoulders (rule switching and inhibition), Backward Digit Span (working memory), and Delay of gratification (inhibitory control, not included in the composite EF score)	Children assigned to fast-paced cartoon, slow-paced cartoon, or drawing (control) conditions (for 9 minutes)	Composite EF scores were lower in the fast-paced cartoon condition compared to the control condition ($p = 0.004$, $\eta^2 = 0.15$). Children's delay of gratification was significantly lower in the fast-paced cartoon condition compared to the control ($p = 0.03$) and slow-paced cartoon conditions ($p = 0.02$, $\eta^2 = 0.12$)	19/22

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[97]	Cross-sectional correlational	161 children aged between 18 and 36 months in southern Taiwan; most mothers (73%) graduated from a college or above	Child's age and sex, prematurity, single-child family, primary caregiver (mother, father, grandparents, and others), and parental education	Child Behavior Checklist for ages 1.5–5 (primary caregiver's report)	Onset age and amount of touchscreen devices use, purpose of using touchscreen devices (education, soothing, recreation, or other), and type of use (playing games, watching films, using educational programs, or other) (primary caregiver estimate)	Children spending more time on touchscreen devices were more likely to have self-regulatory problems with emotion ($\beta = 0.22$, $p < 0.01$, 95% CI: 0.28–1.52), attention ($\beta = 0.30$, $p < 0.001$, 95% CI: 0.43–1.27), and aggression ($\beta = 0.25$, $p < 0.01$, 95% CI: 0.97–3.98)	7/11
[112]	Cross-sectional correlational	A nationally representative sample of 788 American children aged between 2 and 5 years and 391 American children aged between 6 and 8 years	Child's birth order, participation in child care, and vocabulary	Behavior Assessment System for Children-Second Edition (parental report)	Foreground/background TV amount, TV content (parent-reported 24-hour time diary)	For high-risk preschool-aged children, exposure to background TV was negatively associated with EF ($B = 0.59$, $\beta = 0.26$, $p = 0.003$). For preschool-aged children in the low-risk group, foreground watching of narrative-based programs predicted higher EF ($B = -0.0.79$, $\beta = -0.14$, $p = 0.021$)	9/11
[101]	Longitudinal correlational	416 children from the UK, US, and the Netherlands, aged 4 months at time 1 and 14 months at time 2; 37% of mothers had a bachelor's degree, 32% had a master's degree, and 13% had a doctoral degree	Parent age at the time of childbirth, educational attainment, general well-being, anxiety, depression, life satisfaction, self-efficacy in the nurturing role, couple's satisfaction, social support, child's sex, attention, temperament, and country	Prohibition task (inhibitory control), Three Boxes task (working memory), and Ball Run task (cognitive flexibility)	Screen media viewing amount (TV/DVD, tablet, and computer) (parent estimate)	Early screen media exposure was negatively associated with later inhibitory control ($\beta = -4.26$, $p = 0.008$) but not with working memory and cognitive flexibility	12/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[100]	Longitudinal correlational	179 children from the UK, aged 24 months at time 1 and 36 months at time 2; 42% of mothers had a bachelor's degree	Child's age, sex and receptive vocabulary, parent's subjective social status, age at childbirth, and having a bachelor's degree	Multi-Location Search task (working memory), Ball Run task (cognitive flexibility), and Baby Stroop task (inhibitory control) at time 1 Spin the Pots task (working memory), Dimensional Change Card Sorting task (cognitive flexibility), Stroop task (inhibitory control), and Self-Ordered Pointing task (working memory) at time 2	Screen time (TV or DVDs, tablets, phones, and computers) (average time of maternal and paternal estimate)	Screen time at time 1 was negatively associated with composite EF score at time 2 ($\beta = -0.20$, $p = 0.035$) Composite EF score at time 1 was not related to screen time at time 2. No significant association between concurrent screen time and composite EF score	10/14
[103]	Longitudinal correlational	A nationally representative sample of 185 Australian children aged between 3 and 5 at time 1 and between 4 and 6 at time 2	Child's age, sex, average sleep, physical activity and sports participation, quality of the home learning environment, SES, and parental education	Mr. Ant task (spatial working memory), Not This task (phonological working memory), Go/No-Go task (inhibitory control), and Dimensional Change Card Sort task (cognitive flexibility)	Total number of electronic media devices at home, availability of these devices to the child, and amount of use of traditional devices (TV/DVD) and nontraditional devices (tablet, computer, laptop, mobile phone, hand-held game system, and console games) (parent estimate)	Total electronic media use and program viewing at time 1 were not significantly related to different EF components at time 2.Controlling for total program viewing, high-dose application users (≥30 min/day) had lower inhibition scores at time 2 compared to low-dose application users (<30 min/day) (MD = −0.04, 95% CI: -0.09–0; $p = 0.044$, $d = -0.19$)	12/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[98]	Cross-sectional correlational	541 American preschoolers (mean age: 4.1); 52% of mothers had more than high school education	Child's age and sex; parent's age, education, and marital status; income-to-needs ratio; number of adults in the household; parental depressive symptoms; parenting sensitivity	Delay of gratification task (inhibitory control), Social Competence and Behavior Evaluation (teacher report), and Child Behavior Questionnaire (parental report)	Foreground/background TV amount, amount of playing video games, presence of TV in child's bedroom, and frequency of watching TV with meals (parent estimate)	Higher exposure to daily screen media ($\beta = -10.30$, $p < 0.05$) and background TV ($\beta = -12.63$, $p < 0.05$) was associated with shorter waiting times on the delay of gratification task The frequency of background TV ($\beta = 0.04$, $p < 0.05$) and watching TV with meals ($\beta = 0.05$, $p < 0.05$) was related to greater parent-reported difficult temperament If parents had greater depressive symptoms, presence of TV in the bedroom predicted greater parent-reported difficult temperament ($\beta = 0.23$, $p = 0.003$). No association between any of the screen media exposure variables and teacher report of self-regulation	9/11
[6]	Cross-sectional correlational	107 American children aged between 38 and 74 months; 59% of the participants were from low- to middle-income families	Child's age, attendance in preschool, vocabulary, sleep duration, and parental education and income	Grass/snow task, Whisper task, Tower task (inhibitory control), and Backward digit span task (working memory)	Foreground/background TV amount, onset age of TV viewing, and channel and genre viewing (parent estimate)	Children who began watching TV at an earlier age had a lower composite EF score than children with a later onset age of TV viewing ($\beta = 0.30$, $p < 0.001$). Controlling for the onset age of TV viewing, background TV was not associated with EF. Yet, controlling for the onset age of TV viewing and cumulative background TV, foreground TV was negatively associated with EF ($\beta = -0.26$, $p < 0.05$) Controlling for cumulative background and foreground TV, watching educational cartoons was associated with lower EF performance ($\beta = -0.24$, $p < 0.01$), and viewing of Public Broadcasting Service channel was positively associated with the performance on EF tasks ($\beta = 0.23$, $p < 0.01$)	8/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[95]	Cross-sectional correlational	402 American 3-, 4-, and 5-year-olds; on average, mothers received some college education	Child's age and sex, mother's employment status, number of days child attends child care, mother's education, household income, and child's overall TV viewing and evening TV viewing	Early Childhood Behavior Questionnaire (parental report)	Tablet and hand-held game player use amount (parent estimate)	Tablet use was negatively associated with EC ($\beta = -0.11$, $p = 0.029$), but hand-held game player use was positively associated with EC ($\beta = 0.14$, $p = 0.004$). EC was negatively associated with tablet use only when children received less sleep ($\beta = 0.0007$, 95% CI: 0.0001–0.0013). EC was positively associated with hand-held game player use only when children slept more ($\beta = 0.0009$, 95% CI: 0.0001–0.0017)	9/11
[124]	Cross-sectional correlational	107 American children aged between 38 and 74 months; 59% of the participants were from low- to middle-income families	Child's age, parental education and income	Grass/snow task, Whisper task, Tower task (inhibitory control), and Backward digit span task (working memory)	Foreground/background TV amount (parent estimate), presence of TV in child's bedroom	Children's composite EF scores were negatively associated with evening TV view ($r = -0.26$, $p < 0.01$), background TV during daytime ($r = -0.26$, $p < 0.01$), and TV in child's bedroom ($r = -0.24$, $p < 0.05$)	8/11
[109]	Longitudinal correlational	A nationally representative sample of 7,450 American children aged 9 months at time 1 and 2 years at time 2	Child's race/ethnicity, and age, sex, 9-month Bayley Mental and Motor scores, birth weight, parent-rated child health, hours per week in child care, maternal and paternal age, SES, maternal marital status, general health, and depression, prenatal use of tobacco and alcohol, violence against the mother, single-parent household, number of siblings, language spoken at home, neighborhood quality for raising kids, urban household, and parent-child interactions at home	Infant Toddler Symptom Checklist (parental report)	TV/video viewing amount (parent estimate)	Children's self-regulation problems at time 1 were related to increased TV viewing at time 2 (AOR = 0.15; 95% CI: 0.02–0.28). Persistent self-regulation difficulties at both time 1 and time 2 predicted more media use at time 2 (AOR = 1.40; 95% CI = 1.14–1.71). A decrease in children's self-regulation skills was negatively associated with media use (AOR = 1.27; 95% CI = 1.04–1.56)	10/14

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[119]	Experimental	80 children from the UK with a mean age of 71 months	None (groups did not differ on TV viewing duration and TV content)	Both pretest and posttest include the Day/Night task (inhibitory control), Backward Digit Span (working memory), Dimensional Change Card Sort (cognitive flexibility), and Tower of Hanoi (planning)	Children assigned to fantastical cartoon or nonfantastical cartoon conditions (for 23 minutes)	Inhibitory control scores in the fantastical and nonfantastical cartoon conditions were similar in pretest but lower in the fantastical condition in the posttest ($F(1, 78) = 22.89$, $p < 0.001$, $\eta_p^2 = 0.23$). Similar findings were obtained for working memory ($F(1, 78) = 17.21$, $p < 0.001$, $\eta_p^2 = 18$) and cognitive flexibility ($F(1, 78) = 23.87$, $p < 0.001$, $\eta_p^2 = 23$) The decrease in the thinking time to plan a solution in the Tower of Hanoi task was greater in the nonfantastical cartoon compared to the fantastical cartoon condition ($F(1, 78) = 6.76$, $p = 0.011$, $\eta_p^2 = .08$)	17/22
[113]	Cross-sectional correlational	A nationally representative sample of 922 American children aged 3 to 7 years	Child's age and sex, cumulative risk (low family income, single-adult caregiver household, low maternal education, maternal age under 18 at childbirth, and minority background), and child's participation in child care and book reading	Behavioral Assessment for Children-Second Edition (parental report)	Foreground/background TV amount, TV content (parent-reported 24-hour time diary)	Watching entertainment TV ($\beta = 0.12$, p = 0.011) and background TV ($\beta = 0.20$, $p = 0.003$) was positively related to self-regulation problems. Educational TV was not associated with self-regulation problems	10/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[89]	Cross-sectional correlational	807 American children (mean age: 68.6 months) from diverse socioeconomic backgrounds	Child's age, sex, and general intelligence	Hearts and flowers task, Flanker task (inhibitory control), and NIH Toolbox version of the Dimensional Change Card Sort task (cognitive flexibility)	TV amount (parent estimate)	Daily TV viewing was negatively related to children's performance on EF tasks, but this relationship held particularly true for children below ($b = -0.57$, SE = 0.30, $\beta = -0.17$, 95% CI:-0.28 to -0.07, $p = 0.007$) or at the sample mean of the families' income-to-needs ratio ($b = -1.38$, SE = 0.76, $\beta = -0.08$, 95% CI: -0.32 to -0.08, $p = 0.06$). For families above the income-to-needs ratio mean, there was no significant association between television viewing and EF	9/11
[90]	Cross-sectional correlational	381 American children aged between 5 and 12; maternal education distributed proportionally in all levels (high school graduation, college degree, further education)	Maternal education, child's age and sex	A Developmental Neuropsychological Assessment-Second Edition (NEPSY-II) including six domains: Attention and Executive Functioning, Language, Memory and Learning, Social Perception, Sensorimotor, and Visuospatial Processing	TV and computer use amount (parent estimate)	Children's TV viewing was negatively associated with Attention and Executive Functioning scores ($F(1, 366) = 4.15$, $p = 0.04$, $\eta_p^2 = 0.01$, $d = 0.23$). No significant relation between children's computer use and Attention and Executive Functioning scores	8/11
[99]	Cross-sectional correlational	A representative sample of 9,361 American preschoolers aged 2 to 5 years and 30,976 children aged 6 to 17 years	Child's race, sex, and age, household adults' education, family poverty ratio, and family structure (living with two biological/adoptive parents or not)	A composite measure of self-regulation from a caregiver, teacher, and observer report	Screen time (smartphones, computers, electronic games, TV, and electronic devices) (parent estimate)	For children aged 2 to 5 years, high (7+ h/day) and moderate use (4 h/day) of screens predicted lower self-control than low screen use (1 h/day) ($d = -0.41$, $p < 0.05$; $d = -0.25$, $p < 0.05$, respectively). Compared to low users, high (RR 1.99, CI: 1.44–2.77, $d = -0.29$, $p < 0.05$) and moderate users (RR 1.33, CI: 1.02–1.72, $d = -0.16$, $p < 0.05$) were more likely to lose their temper	7/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[105]	Longitudinal correlational	4983 Australian children aged 4-5 years at time 1 and 6-7 years at time 2; 22% of mothers with incomplete high school education and 28% of mothers with university education	Earlier self-regulation, child's gender, age of assessment at baseline, birth weight, whether or not the child had ever been breastfed, Aboriginal and Torres Strait Islander status, non-English speaking home background, maternal education level, and household income bracket	A composite score of self-regulation from parent, teacher, and observer reports with a 20-item survey including constructs of impulsive aggression, hyperactivity, lack of persistence/inattention, and impulsivity	TV and computer use amount (parent estimate)	No significant association between TV and computer use at time 1 and self-regulation at time 2	8/14
[93]	Cross-sectional correlational	119 Chinese children aged between 3 and 6 years; 67% of mothers were college educated, and nearly 70% of participants' household income was above the national average income	Child's age, sex, and vocabulary, maternal education, and family income	Backward Digit Span task, Spatial Span task (working memory), Boy-Girl Stroop, Simon task, Flanker task (inhibitory control), and Tower of Hanoi task (planning)	Onset age and amount of TV viewing, channel and genre viewing (parent estimate)	Higher TV viewing amount predicted better composite EF ($\beta = 0.15$, $p < 0.01$, Cohen's $f^2 = 0.06$). Controlling for children's TV viewing amount, watching classical cartoons ($\beta = 0.23$, $p < 0.001$, $f^2 = 0.27$) predicted better composite EF, whereas parental restrictive approach predicted worse EF ($\beta = -0.18$, $p < 0.01$, $f^2 = 0.1$). Both watching classical cartoons ($\beta = 0.24$, SE = 0.11, 95% CI: 0.08–0.53) and live educational shows ($\beta = 0.10$, SE = 0.06, 95% CI: 0.01–0.29) acted as mediators between TV viewing amount and EF. Parental restrictive approach moderated the direct relationship between TV time and EF such that TV viewing amount had a positive effect on EF only at the low level of restrictive approach ($\beta = 0.76$, SE = 0.33, 95% CI: 0.10– 1.42). Only when parental restrictive approach was at a low or moderate level, TV time had a positive indirect effect on EF via watching classical cartoons ($\beta = -0.17$, SE = 0.12, 95% CI: -0.47 to -0.003)	8/11

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Table 1: Continued.

Study	Study design	Sample	Covariates	Measurement of self-regulation	Measurement or manipulation of screen media use	Main findings	Quality
[94]	Cross-sectional correlational	119 Chinese children aged between 3 and 6 years; 67% of mothers were college educated.	Child's age and gender and family SES	Backward Digit Span task, Spatial Span task (working memory), Boy-Girl Stroop, Simon task, Flanker task (inhibitory control), and Tower of Hanoi task (ToH) (planning)	Electronic game play time on smartphone, tablet, computer, and game console (none, <1 hour, 1-2 hours, and >2 hours for each platform) electronic game content (parent estimate)	Electronic game playing time predicted better composite EF scores ($\beta = 0.81$, SE = 0.24, $\beta = 0.19$, $p < 0.001$). Game playing time predicted better scores on the backward digit span ($\beta = 0.14$, $p = 0.041$), on the ToH ($\beta = 0.24$, $p = 0.003$), and on the Simon task ($\beta = 0.18$, $p = 0.034$) Action game content was negatively associated with inhibitory control in flanker task ($\beta = -0.20$, p = 0.012) but not significantly associated with working memory or planning. Both prosocial and action content were not associated with composite EF	9/11

Note: EF: executive function; SES: socioeconomic status.

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Table 2: Summary of included studies according to their themes.

Study	Screen time		Screen media content				Contextual factors	
	Concurrent relations between screen time and self-regulation	Predictive relations between screen time and self-regulation	Screen time in infancy	Educational vs. entertainment content	Fantastical content	Long-term effects	Background TV	Parent-related factors
[85]	✓							
[114][a]								
[110]		✓	✓				✓	
[104]		✓						✓
[91]	✓							
[7]		✓	✓					✓
[96]	✓							
[123]						✓		
[122]						✓		
[102]		✓						✓
[87]	✓			✓			✓	✓
[86]	✓							
[111]				✓	✓			
[88]	✓	✓						
[115]					✓			
[92]	✓							
[120]					✓			
[116]					✓			
[118]					✓			
[117]					✓			
[121]					✓			
[97]	✓		✓					
[112]				✓			✓	✓
[101]		✓	✓					✓
[100]	✓	✓	✓					
[103]		✓						
[98]	✓						✓	✓
[6]	✓		✓	✓				
[95]	✓							
[124]							✓	
[109]		✓						
[119]					✓			
[113]				✓			✓	
[89]	✓							
[90]	✓							
[99]	✓							
[105]		✓						
[93]	✓			✓				✓
[94]	✓							
Total number of studies in each category	17	10	6	5	8	2	6	8

Note: [a]Antrilli and Wang [114] investigated the effects of physical vs. touchscreen play on executive functions; therefore, this study did not belong to the categories listed in the table.

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4.3. Screen Media Content

4.3.1. Entertainment vs. Educational Content. In most of the studies that collected data on TV content, the content was classified as either educational or entertainment (i.e., content without an educational value). In terms of the relationship between watching educational content and self-regulatory skills, studies showed both negative [6], positive [87], and null findings [93, 111–113]. Similarly, while some studies reported that watching entertainment content was positively related to self-regulation ([112] for low-risk children; [93, 113]), others demonstrated a nonsignificant relationship [6]. Thus, regarding TV content, the findings demonstrate some contradictions.

In terms of the relationship between electronic game play and self-regulation, our current knowledge is limited. One study demonstrated that children show better cognitive flexibility after a short amount of physical play compared to touchscreen play [114]. How the content of electronic games may be related to children's regulatory skills was only investigated by one study that reported negative relations between action content and inhibitory control and no significant relations between action and prosocial content and composite executive function measures [94]. Thus, more studies are needed to investigate how game content may be related to self-regulation in young children.

4.3.2. Fantastical Content. Physically impossible and hence fantastical events are commonly used in child-directed TV and videos. Comprehension of fantastical events may be cognitively taxing due to their novelty and rarity in daily life, resulting in excessive consumption of resources [115–117]. It has been suggested that executive functions and processing fantastical events may rely on the same cognitive resources; thus, watching fantastical events may have immediate negative effects on executive functioning (e.g., [118]). To test this hypothesis, a series of studies investigated the short-term effects of watching fantastical content on young children's executive functions and reported poorer performance on executive function tasks after watching fantastical events [115–117, 119]. These findings were complemented by higher activation of the brain and frequent and shorter eye fixations while watching a higher number of fantastical events, potentially indicating more cognitive effort [116]. An exception was the study by Kostyrka-Allchorne et al. [120] reporting that inhibitory control showed an increase after watching unrealistic content, albeit the effect size for this increase was rather small ($\eta_p^2 = 0.025$). Unlike other studies using cartoons, this study used movies consisting of a narrator along with story-related images, which may have rendered the procedure more similar to book reading than watching a typical cartoon.

Interacting with fantastical events such as playing a fantastical game may have different effects on executive functions compared to watching these events. Interactivity may allow multimodal stimulation, such that children can see, hear, touch, and manipulate images and characters on the screen. This multimodal stimulation may render the perception of fantastical events as more realistic [118]. So far, only one study investigated the differences between the immediate effects of watching vs. interacting with fantastical content and reported poorer outcomes in terms of inhibitory control for watching compared to interacting [118]. More studies are needed to investigate the differential effects of watching and interacting with fantastical events on children's executive functions.

Apart from whether fantastical content is presented in an interactive way or not, the pace of presentation may also matter. Attention-grabbing properties of screen media such as fast pace may trigger bottom-up attentional processes [56] and negatively affect self-regulatory skills, which require top-down control of attention [2]. So far, studies testing the effect of slow vs. fast pace while keeping the number of fantastical events similar in both conditions did not report any significant effects of pace on children's executive functions [117, 120]. On the contrary, children showed a poorer delay of gratification ability after watching a fast-paced compared to a slow-paced show in Lillard and Peterson [121]; however, the fantastical content was a confound in this study since the fast-paced show was fantastical but the slow-paced one was realistic.

In sum, the majority of the studies investigating the immediate effects of fantastical content on young children's executive functions reported negative effects with effect sizes ranging from medium to large. Furthermore, the negative effects of watching fantastical content on behavioral outcomes were supported by studying eye movements and brain activation patterns.

4.3.3. Long-Term Effects. In terms of how the content of screen media relates to children's self-regulatory skills, the majority of the studies were concerned with the immediate negative effects of viewing or interacting with fantastical content. On the other hand, two early experimental studies investigated the long-term effects of viewing different types of TV content on children's various developmental outcomes such as behavior problems, peer relations, prosocial behaviors, and self-regulation. Their findings showed that children's tolerance of delay, namely, the ability to voluntarily wait for materials or adult attention when these are not immediately available, increased after a long-term exposure to prosocial TV content such as cooperation, sharing, and sympathy and decreased after being exposed to aggressive TV content such as physical violence and verbal aggression [122]. Similarly, a long-term exposure to prosocial TV content led to positive changes in children's social interactions, imaginative play, and aggression but not in self-regulation [123]. These two studies are the only ones that provide information about the effects of long-term manipulation of screen media content.

In general, the studies examining the relationship between children's self-regulation and screen media content demonstrated (1) immediate negative effects of watching fantastical content on executive functions and (2) mixed findings in terms of the relationship between educational and entertainment TV and self-regulation.

4.4. Contextual Factors

4.4.1. Background TV. In terms of the relation of background TV to children's self-regulation, studies were in agreement:

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background TV was positively related to children's self-regulation problems [113] and negatively related to executive functions ([112], only for high-risk children; [124]). Similarly, watching adult-directed shows, which may function as background TV [125], was negatively related to children's cognitive skills, including executive functions [87, 110]. Additionally, children more frequently exhibiting difficulties in regulating their emotions and behavior were exposed to longer durations of TV during meals and background TV [98]. Overall, regarding background TV, studies suggest that it is negatively related to young children's ability to self-regulate.

4.4.2. Parent-Related Factors. Parental behaviors can facilitate or hinder the development of children's self-regulatory skills. Three studies found that after controlling for parent-related factors such as hostile and positive parenting, general well-being, and anxiety, early screen time (age ≤ 3) was still negatively related to later self-regulation [7, 101, 102]. On the contrary, Blankson et al. [104] found that early TV exposure was negatively associated with later executive functions, but this relationship was no longer statistically significant after controlling for mothers' scaffolding behaviors and features related to the home learning environment such as the presence of cognitively stimulating toys. This study differed from the three studies reporting negative relations in that maternal behaviors were measured via observation rather than self-report.

Instead of using parent-related factors as control variables, two studies examined the moderating role of these factors between children's screen media use and self-regulation. These studies did not report a significant moderating role for parental inconsistency and responsiveness [112] and parental sensitivity [98]. Overall, there is weak evidence for a protective role of positive parental behaviors against the probable negative effects of screen media use.

Parental restrictions on children's use of screen media may also be relevant to the relationship between children's screen media use and self-regulation as parents may limit their children's screen time and the content they are exposed to on screens. Parental limitations on children's TV time and content predicted better cognitive and social skills, including executive functions and self-control [87]. However, after controlling for demographic factors and screen time and content, the restrictions did not significantly predict children's cognitive and social outcomes. Contrary to expectations, Yang et al. [93] found that only if the parental restrictive approach was at a low level, TV viewing duration was positively related to executive functions. The authors argued that parents might be more restrictive for children with poorer executive functioning skills. Overall, the findings of these two studies about parental restrictions are not conclusive, and more research is needed to examine the moderating role of parental restrictions.

5. Discussion

The main purpose of this review was to provide a comprehensive summary of the literature regarding the relations between young children's screen media use and their self-regulatory skills. Specifically, we focused on the relation of children's self-regulation to screen time, screen media content, and screen media context. The key findings in response to the six questions that this review aimed to answer can be listed as follows: (1) screen time is not consistently negatively associated with children's self-regulation; (2) inconsistent findings were reported for both traditional and interactive media; (3) screen exposure in infancy is negatively related with self-regulation; (4) watching fantastical content seems to have immediate negative effects on children's executive functions, and watching educational content does not seem to have positive effects; (5) background TV is negatively related to children's self-regulatory skills; and (6) studies mostly do not lend support to the claim that certain parenting practices and behaviors are protective against the potential negative consequences of screen exposure. In the discussion that follows, we will elaborate on each of these key findings.

5.1. Screen Time. Studies testing concurrent and predictive relationships between screen time and self-regulation produced inconsistent results. An explanation of this inconsistency may be that screen time by itself is not a completely adequate measure of screen exposure. It has been suggested that children's screen exposure should not only be assessed in terms of screen time but also in terms of parental attitudes towards media use, parental mediation of media use, and the amount of background TV in the household [69]. Another potential explanation of inconsistent findings is related to *how* screen time is measured. Most of the studies assessed screen time by parent estimate; however, parental reports may be biased as parents have been found to underreport (36% of parents) or overreport (35% of parents) their young children's use of mobile devices [126]. It is possible that parents report incorrect information due to social desirability bias or their lack of awareness about their children's media use. Asking parents to keep a diary of their children's screen media use could lead to more accurate assessments of screen time. Only a small number of studies reviewed here used the diary method to collect more detailed data [110, 112, 113]. Collecting diary data from parents could both render the classification of the media content easier and enable further investigation of screen time such as whether a bulk of screen time (e.g., 2 hours of TV after lunch) has different effects than more scattered screen time throughout the day (e.g., 1 hour of TV after lunch and 1 hour of TV after dinner).

Consistently, studies found that screen exposure in infancy predicts poorer self-regulatory skills. Coupled with the findings showing that an earlier onset of screen exposure is negatively associated with executive functioning [6], these findings suggest that screen exposure before age two is detrimental to the development of self-regulatory skills. One way for early screen exposure to have a damaging effect is that TV/videos may stimulate low-level instead of high-level attentional processing via rapid visual changes [56], which could impair attentional control skills that underlie self-regulation. Supporting this hypothesis, a recent study showed that preschool-aged children had lower attentional

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control skills if they had a longer duration of touchscreen use from toddlerhood to preschool ages [127]. Another explanation for why early screen exposure is related to poorer self-regulation may be that the content being watched is mostly incomprehensible for infants. Just like watching fantastical content has immediate negative effects on preschool-aged children's executive functions, watching TV/videos and especially adult-directed content may create a cognitive load and have short-term negative effects on emerging self-regulatory skills of infants. Finally, infants are wired to learn from social interactions. From a young age onwards, they prefer to look at faces, prefer speech and particularly child-directed speech over other signals, and pay attention to social cues [128–131]. The lack of interactivity in screen media seems to create an obstacle for infant learning. Supporting this argument, Myers et al. [132] found that 17- to 25-month-olds demonstrated word and pattern learning by interacting with an adult over FaceTime but failed to do so after watching a prerecorded video of the same person. In terms of self-regulation, behaviors such as learning to wait and dealing with frustration are likely to be more easily learned from social interactions and by observing caregivers as role models instead of watching the interactions between the characters on screen.

In terms of the distinction between traditional and interactive media, we do not have conclusive evidence. For both types of screen media use, inconsistent findings have been reported. Particularly, there is no evidence for a strong connection between interactive media use and self-regulation in children. An explanation of these findings may be that interactive devices can be used both passively (such as for watching videos) and actively (such as for playing games and using applications), and these different types of use may have different effects on children's attention and behaviors related to self-regulation. A drawback of most of the studies that assessed the amount of children's interactive media use was that how and for what purposes children use mobile devices was not measured.

5.2. Screen Media Content. What children watch on TV may be more important than how much they watch [63]. Experimental studies seem to agree that watching fantastical content has immediate negative effects on children's executive functions and that children are likely to show a poorer performance on executive function tasks and more brain activation after watching fantastical content which indicates that the processing of fantastical events requires cognitive effort from young children. A future direction may be to investigate the cumulative long-term effects of watching fantastical content since all studies so far examined immediate effects. Whether watching fantastical events creates a similar cognitive load for older children may also be examined by future studies since compared to younger children, older children (and adults) may find fantastical events easier to process. Furthermore, if processing fantastical content is taxing for young children's cognitive resources, it can be tested whether using a simple and explanatory language of the events to accompany the visuals would alleviate this cognitive load.

Apart from fantastical content, some studies investigated whether watching educational content benefitted children's self-regulatory skills. Out of five studies coded for TV content, only one reported positive associations between watching educational content and self-regulation. A recent analysis of child-directed applications that were advertised as educational showed a low educational quality for most of the applications analyzed [133]. Although we are not aware of such an analysis for TV shows, it may be that the TV shows/cartoons categorized as educational may likewise have low educational value. There is also the possibility that educational content is more important for the development of vocabulary and general knowledge but not for the development of self-regulation.

In terms of whether watching entertainment TV relates to children's self-regulation, the findings were inconsistent as some studies showed a positive relationship and others reported null findings. An explanation of these inconsistent findings may be that the TV shows that were categorized as entertainment TV may vastly differ from each other in terms of their narrative structure, action content, and pace (e.g., *Tom and Jerry* and *SpongeBob*). More fine-grained analyses of the content (e.g., fantastical content, action content, and prosocial content) and the way the content is presented (e.g., use of visually/auditorily salient features such as sound effects, the presence, or absence of dialogue) seem to be necessary.

5.3. Background TV. Consistently, studies found that background TV and watching adult-directed content are negatively associated with children's emerging self-regulatory skills. It is known that high-quality interactions and parental behaviors are associated with better development of self-regulatory skills [34, 55]. One way for background TV to be related to children's self-regulation is through decreasing the quantity and quality of parent-child interactions and positive parental behaviors towards children [75, 76, 134, 135]. Another way for background TV to have an effect on self-regulation may be through children's attentional skills. Experimental studies showed that young children sustain their attention on toys for shorter periods of time while the TV is on in the background [77, 136]. Frequent exposure to background TV may have cumulative negative effects on children's attentional control skills that are thought to lay the foundation for self-regulation [58].

5.4. Parental Behaviors and Parental Restrictions on Screen Media Use. Spending quality time with parents and experiencing positive parenting behaviors such as sensitivity and scaffolding may alleviate the negative effects that screen media use may have on child development. Studies mostly did not report such a protective or moderating role of parental behaviors. The only piece of evidence indicating a protective role of parents came from Blankson et al. [104], where the negative association between screen time and self-regulation was rendered insignificant after controlling for parental scaffolding and the home learning environment. Importantly, the studies that did not report a significant role for parenting measured aspects of parental behaviors via self-

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report while the study reporting a significant role for parental scaffolding used an observational method to assess parental behaviors. We suggest that future studies use observation to assess parental behaviors and focus on specific behaviors that provide support for the development of self-regulation, such as autonomy support and scaffolding [55, 137].

The role of parental restrictions in the relationship between children's screen media use and self-regulation was not studied widely. More studies are needed where the role of parental restrictions is interpreted in relation to parental education and family income since these factors are significantly associated with parental attitudes towards children's screen media use [108, 138].

5.5. Limitations and Future Directions. The theoretical approaches that aim to explain how the development of self-regulation might be related to children's use of screen media were not tested by the majority of the studies. For instance, the displacement hypothesis argued that longer durations of screen time may be detrimental since screen time might displace the time that could be spent with caregivers on activities that support the development of self-regulation [52]. One way to test this hypothesis would be to measure the proportion of time children spend on doing different activities like watching TV, participating in sports, being engaged in hobbies, and doing homework [139]. To date, no study directly tested this hypothesis in relation to the development of self-regulation. Another hypothesis linking screen media use to children's attention and cognitive development suggests that low-level, perceptually salient visual changes found in child-directed TV/videos capture children's attention so that over time, children may rely on external stimuli more than internal goals to guide attention [56]. Current evidence suggests that the pace of the program does not have any immediate effects on children's executive functions [117, 120], but more studies are needed to understand how formal features such as editing and the presence of sudden visual effects have an effect on children's attention and self-regulation.

We know that children from low-income countries use the Internet the least, and their digital experiences are less documented [13]. Thirty-seven of 39 studies reviewed here were conducted in high-income countries, and the remaining two studies were conducted in upper-middle-income countries (classified according to the [140]). More studies are needed to investigate how children's use of screen-based technologies in low-income countries relates to their self-regulation. Another limitation of the current literature was the lack of focus on the content of screen media children consume. As for the studies that measured content, they tended to omit information about how different content categories (such as educational and entertainment) were coded. Furthermore, although numerous findings demonstrate that playing aggressive video games is associated with attention problems and aggressive thoughts and behaviors in children and adolescents [51, 141, 142], only one study [122] investigated the effects of watching aggressive content on children's self-regulation. More studies are needed to investigate how watching or interacting with aggressive and action content relates to young children's self-regulation.

Although we mostly focused on the negative associations between children's screen media use and self-regulation, it may be that certain types of screen media use may have positive effects. For instance, one of the factors that was overlooked by the studies reviewed here was whether and how joint media engagement, in other words, sharing media experiences with another partner [143] such as a caregiver or a sibling, may have different effects compared to using screen media alone. Another factor that may lead to more positive outcomes may be interacting with prosocial content. Playing prosocial video games where game characters help and support each other is associated with positive outcomes such as increased prosocial behaviors and decreased aggressive cognition for children and adults [142, 144–146]. Future studies should examine the immediate and long-term effects of exposure to prosocial interactive content on children's self-regulation. Furthermore, our current knowledge about whether and how touchscreen play affects children's attention and self-regulation is highly limited. It may be that an interactive use of screens with high-quality apps may yield positive effects. Finally, since physical activity has been shown to promote the development of executive functions [147], games and game consoles that combine screen-based activity with physical activity (such as *Just Dance* and *Nintendo Wii Fit*) may yield positive outcomes in terms of self-regulatory skills.

In the current review article, we deliberately did not focus on the studies that investigate the relationship between children's screen media use and their attention-related behaviors, such as focused attention and inattention, and ADHD-related behaviors such as impulsivity and hyperactivity. Given that attentional control is thought to be related to the development of regulation-related behaviors [28, 148], future review studies and meta-analyses can focus on the findings of the studies investigating the relationship between children's screen media use, attention-related behaviors, and attention problems.

Disclosure

The present study was presented at the Budapest CEU Conference on Cognitive Development (2022) and APA Technology, Mind, and Society Conference (2021) as a poster.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Supplementary Materials

The supplementary material includes four different checklists for the quality assessment of different types of studies, namely, cross-sectional experimental, longitudinal experimental, cross-sectional correlational, and longitudinal correlational studies. *(Supplementary Materials)*

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