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# Associations Between Screen Use and Child Language Skills
## A Systematic Review and Meta-analysis

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**IMPORTANCE** There is considerable public and scientific debate as to whether screen use helps or hinders early child development, particularly the development of language skills.

**OBJECTIVE** To examine via meta-analyses the associations between quantity (duration of screen time and background television), quality (educational programming and co-viewing), and onset of screen use and children's language skills.

**DATA SOURCES** Searches were conducted in MEDLINE, Embase, and PsycINFO in March 2019. The search strategy included a publication date limit from 1960 through March 2019.

**STUDY SELECTION** Inclusion criteria were a measure of screen use; a measure of language skills; and statistical data that could be transformed into an effect size. Exclusion criteria were qualitative studies; child age older than 12 years; and language assessment preverbal.

**DATA EXTRACTION AND SYNTHESIS** The following variables were extracted: effect size, child age and sex, screen measure type, study publication year, and study design. All studies were independently coded by 2 coders and conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.

**MAIN OUTCOMES AND MEASURES** Based on a priori study criteria, quantity of screen use included duration of screen time and background television, quality of screen use included co-viewing and exposure to educational programs, and onset of screen use was defined as the age children first began viewing screens. The child language outcome included assessments of receptive and/or expressive language.

**RESULTS** Participants totaled 18 905 from 42 studies included. Effect sizes were measured as correlations ($r$). Greater quantity of screen use (hours per use) was associated with lower language skills (screen time [n = 38; $r$ = −0.14; 95% CI, −0.18 to −0.10]; background television [n = 5; $r$ = −0.19; 95% CI, −0.33 to −0.05]), while better-quality screen use (educational programs [n = 13; $r$ = 0.13; 95% CI, 0.02-0.24]; co-viewing [n = 12; $r$ = 0.16; 95% CI, 0.07-.24]) were associated with stronger child language skills. Later age at screen use onset was also associated with stronger child language skills [n = 4; $r$ = 0.17; 95% CI, 0.07-0.27].

**CONCLUSIONS AND RELEVANCE** The findings of this meta-analysis support pediatric recommendations to limit children's duration of screen exposure, to select high-quality programming, and to co-view when possible.

Supplemental content

CME Quiz at jamacmelookup.com and CME Questions page 735

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For decades, there has been scientific debate as well as considerable public discourse as to whether screen use, defined as television or screen exposure, helps or hinders early child development. This debate has been reignited in the last decade, as children's access to and consumption of digital media is on the rise.[1,2] The debate primarily centers around quantity vs quality of screen use. In terms of quantity of screen use (ie, hours per day/week), it has been argued that screen use can be a passive or sedentary behavior that can displace critical learning opportunities for growth and development,[3,4] such as language. That is, when young children are exposed to screens, they are not engaging in verbal dyadic exchanges that have been shown to promote communication and language acquisition.[5,6] However, there is research to support and refute the notion that increased quantity of screen use is linked with delayed language acquisition.[3,5,7,8]

In terms of quality of screen use, it is purported that context (co-viewing) and content (educational programming) may offset some of the developmental risks associated with screen use.[9] That is, quality of programming may serve to augment rather than inhibit child language.[10] Some researchers have disputed this claim and argued that this notion is based on misleading marketing claims that certain screen-based programming will help children garner knowledge and enhance intellect.[11] From an empirical perspective, there is mixed evidence as to whether screen-based programming that is deemed educational can be effective in teaching language to children[12,13] and whether co-viewing facilitates child language acquisition.[6,14]

To adequately evaluate all sides of the debate, this meta-analysis will examine the association between screen use and children's language skills. Specifically, 3 components of screen use will be explored: quantity of use (ie, hours of screen time and background television), quality of use (ie, educational and co-viewing), and age at screen exposure onset. We also examine potential moderators of these associations to explain heterogeneity in study findings, including child age, because it has been argued that there may be a sensitive period in which screens may exert their influence on language[15]; child sex, given the proclivity for boys to lag behind girls in their early language development[16]; and study year, given the rapid growth in the use and accessibility of digital technology.[1] We target child language in particular because it is one of the most frequently studied correlates of screen time, is considered to be one of the earliest markers of developmental risk, and is a common reason for referral to pediatric specialists.[17,18] Moreover, deficits and delays in language skills are in turn linked with a myriad of negative outcomes, such as psychopathology, poor school readiness, delayed academic achievement, and poor occupational functioning.[19,20] These deficits and delays in language skills can set the stage for developmental disparities. Identifying modifiable environmental factors that can augment or attenuate language skills are essential, not only for optimizing child developmental trajectories but also to inform policy recommendations.

The American Academy of Pediatrics recommends no screen exposure before age 18 months, that children between ages 2 and 5 years view no more than 1 hour of high-quality programming per day and to co-view if possible, and that children older than 6 years receive consistent limits on the quantity and quality of screen use.[21] While these recommendations have been adopted by many international governing bodies,[22-26] they have also been criticized for lacking empirical support.[27-29] Thus, this study endeavors to resolve the existing debate and provide more definitive conclusions via meta-analyses on the role of screen use for children's language, with the goal of informing policy, research, and practice.

**Key Points**

**Question** What is the association between screen use and children's language skills across the extant literature?

**Findings** In this systematic review and meta-analysis of data from 42 studies, greater quantity of screen use (ie, hours per day/week) was negatively associated with child language, while better quality of screen use (ie, educational programs and co-viewing with caregivers) were positively associated with child language skills.

**Meaning** Findings support pediatric recommendations to limit screen exposure, to provide high-quality programming, and to co-view when possible.

## Methods

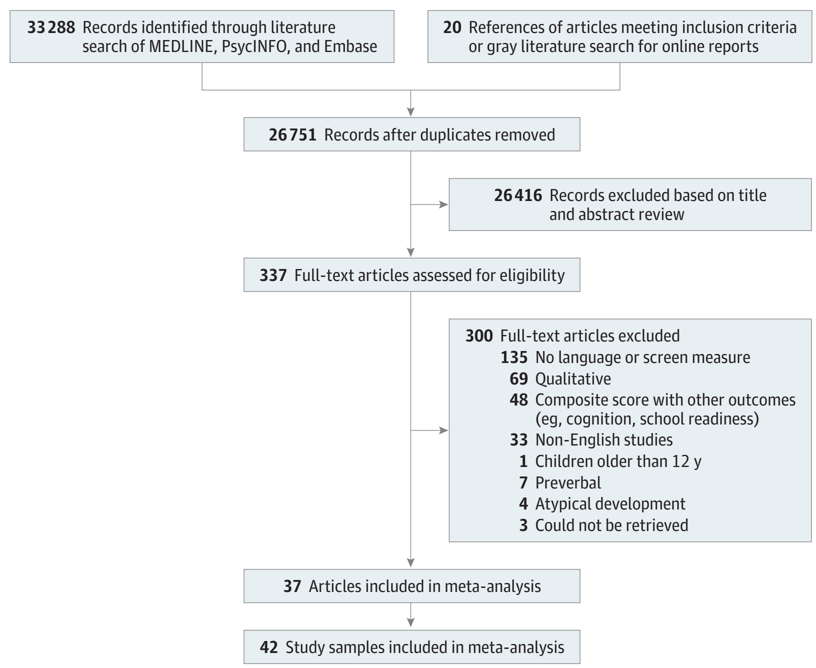
### Definition of Constructs

*Quantity* of screen use included duration of screen time, defined as duration of time spent watching television, movies, or DVDs on devices (eg, tablets or televisions), as well as background television, typically reported in hours per day/week. *Quality* of screen use included co-viewing or how often caregivers joined their children while exposed to screens, as well as extent of exposure to educational programs (eg, *Sesame Street*). We included educational programs when authors deemed them as such (see study specific definitions in eTable 1 in the Supplement). *Onset* of screen use was defined as the age children first began viewing screens. In terms of child language, this study included assessments of receptive (eg, Peabody Picture Vocabulary Test)[30] or expressive (eg, MacArthur Communicative Development Inventory)[31] language assessed using parent-report questionnaires or standardized assessments.

### Search Strategy

Searches were conducted in MEDLINE, Embase, and PsycINFO in March 2019 by a health sciences librarian. Both database-specific subject headings and text word fields were searched for concepts of "screen time" and "language" (see full search strategy in eTable 2 in the Supplement). Synonymous terms were first combined with the Boolean "OR." These 2 concepts were then combined with the Boolean "AND." The concept of children (<12 years) was searched using both the "Age Limits" function in the databases as well as with a text word search and combined with the other 2 concepts. In all databases, truncation symbols were used in

Figure 1. PRISMA Flow Diagram Detailing the Search Strategy




text word searches when appropriate. In MEDLINE and PsycINFO, the search strategy included a publication date limit from 1960 through March 2019. The Embase segment that was accessed originated in 1974. No language limits were applied. References of all included studies, as well as review articles, were also searched.

## Study Inclusion and Exclusion Criteria

The titles and abstracts of all studies emerging from the search strategy were reviewed by 2 independent coders to determine inclusion criteria, which were as follows: (1) mean sample age 12.0 years and younger to capture language when it is maximally unfolding; (2) a measure of screen use; (3) a measure of language skill (ie, expressive, receptive, or combined); (4) observational study; and (5) statistical data that could be transformed into an effect size. If effect sizes could not be extracted from the study (n = 3), the corresponding author was contacted (authors provided data). As detailed in **Figure 1**, studies were excluded if (1) they were qualitative; (2) they included children older than 12 years; (3) the language measure was preverbal (eg, babbling) or was a composite score with other nonlinguistic skills (eg, IQ); (4) the sample had children with autism spectrum disorder or intellectual disabilities; or (5) the study was experimental and without baseline measures prior to experimentation.

## Study Quality Assessment

The quality of included studies was assessed based on a 10-point quality assessment tool adapted from the National Institutes of Health Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies[32] (eTable 3 in the Supplement). Extraction of methodologic quality was conducted by a primary coder, and 20% of the studies were verified by a second coder. The intercoder agreement was 0.80, and discrepancies were resolved through consensus.

## Data Extraction

In addition to the calculation of effect sizes, the following moderator variables were extracted: (1) child age (in months), (2) child sex (percentage male), (3) screen use type (mobile only vs television only vs mixture of television, mobile, computers, and/or video games), (4) study publication year, (5) study design (cross-sectional vs longitudinal), and (6) study methodologic quality. All studies meeting inclusion criteria were independently coded by 2 trained coders. Reliability for continuous moderators ranged from 0.86 to 1.00 and for categorical moderators, the mean percentage agreement was 81%. Discrepancies were resolved through consensus.

## Data Synthesis

If there were multiple studies based on the same data set, we selected the study with the largest sample size, readily available statistics, and psychometrically sound measurement. If adjusted and unadjusted effect sizes were provided, we selected adjusted (eTable 4 in the Supplement). If a single study assessed screen time and, for example, background television, both effect sizes were extracted and examined in separate meta-analyses. If more than 1 measure of language was provided (eg, receptive and general language), the most global assessment of child language was selected. If language was assessed at multiple points, we selected the latest point to capture the most developed language skills.[33,34] When cross-sectional and longitudinal correlations were provided, we selected the most temporally distant effect size. If within a study, effect sizes from independent cohorts were provided, they were entered into the meta-analysis separately.

### Data Analysis

Comprehensive Meta-Analysis Software, version 3.0 (BioStat)[35] was used to estimate pooled effect sizes and conduct moderator analyses. When nonsignificant findings (n = 4) were reported without accompanying statistical information, a *P* value of .50 was entered, consistent with recommendations by Rosenthal.[36] Pooled effect sizes are represented as correlations (*r*) with 95% CIs. Funder and Ozer[37] suggest that correlations of 0.1, 0.2, and 0.3 are indicative of small, medium, and large effects sizes, respectively. Calculations were based on a random-effects model using the DerSimonian and Laird estimator[38] to account for existing heterogeneity among studies.[36] Outlier detection was examined in SPSS (IBM)[39] using visual inspection of box plots. Test of heterogeneity of effect sizes were examined with and without outliers to determine whether moderator analyses should be explored. To assess for heterogeneity of effect sizes, we computed the *Q* and $I^2$ statistics. Moderators should be explored when a significant *Q* statistic is detected and/or when an $I^2$ is less than 50%.[24] Significance of categorical and continuous moderators was determined by the *Q* statistic and by mixed-effects model meta-regressions (method of moments), respectively.[36,38,40] Consistent with recommendations by Borenstein et al,[38] categorical moderators were only analyzed when *k* was at least 10 and a minimum cell size of *k* greater than 3 was available for each categorical comparison. To detect for publication bias, we used the Egger test and an examination of funnel plots.

## Results

### Studies Selected

The PRISMA flow diagram (Figure 1) details the search strategy and results. The initial search identified 26 751 records. Full-text review occurred for 337 articles. A total of 42 studies (18 905 participants) met inclusion criteria and were included in the final analyses.

### Sample Characteristics

Of the studies included (**Table**),[3,5-8,10,13-15,41-68] 24 were cross-sectional and 17 were longitudinal, sample size ranged from 19 to 2335 participants, and publication year ranged from 1973 to 2019. Children were approximately aged 35.7 and 44.4 months at the screen use and language measurements, respectively, and sex was on average 50.2% male (n = 9490). Measurement included questionnaires (n = 17; 41.5%), with a smaller number of studies using screen time diary (n = 13; 31.7%), interview (n = 10; 23.4%), or observer (n = 1; 0.2%) methods. Most studies examine screen use via television exclusively (70.7%) or a composite of television and/or computers, mobile use, and video games (24.4%), and a minority examined mobile use only (4.8%). The mean (SD) quality score was 6.21 (1.69) (range, 3.00-9.00; eTable 4 in the Supplement).

### Meta-analytic Results for Quantity of Screen Use

#### Duration of Screen Use

A total of 38 studies (18 313 participants) were available for this random-effects meta-analysis, which produced a significant and negative combined effect size $r = −0.14$ (95% CI, −0.18 to −0.10; **Figure 2**). Thus, greater quantity of screen use was associated with lower child language. The funnel plot inspection revealed asymmetry (eFigure 1 in the Supplement), and the Egger test suggested that studies with smaller sample sizes had more extreme effect sizes. A sensitivity analysis was conducted to determine the presence of potential outliers, and 1 study was identified. There was evidence of significant between-study heterogeneity of effect sizes with ($Q_B = 226.58$; $P < .001$; $I^2 = 83.67$) and without ($Q_B = 169.57$; $P < .001$; $I^2 = 78.77$) the outlying study. All moderators are reported in eTable 5 in the Supplement; none emerged as significant.

#### Background Television

A total of 5 studies (2792 participants) produced a pooled effect size of $r = −0.19$ (95% CI, −0.33 to −0.05; Figure 2). Thus, background television was associated with decreased language skills. No outliers were detected. Asymmetry was revealed in the funnel plot (eFigure 2 in the Supplement), but the Egger test did not suggest publication bias. There was evidence of effect size heterogeneity ($Q_B = 17.00$; $P < .001$; $I^2 = 76.47$), but no moderators examined explained between-study variation (eTable 6 in the Supplement).

### Meta-analytic Results for Quality of Screen Use

#### Educational Content

A total of 13 studies (1955 participants) produced a significant and positive combined effect size $r = 0.13$ (95% CI, 0.02-.24; **Figure 3**). Thus, viewing educational content was associated with increased language skills. No publication bias was detected (eFigure 3 in the Supplement). There was evidence of significant between-study heterogeneity of effect sizes with ($Q_B = 67.12$; $P < .001$; $I^2 = 82.12$), and without ($Q_B = 32.36$; $P < .001$; $I^2 = 66.01$) the outlying study. Moderators were explored, but none emerged as significant (eTable 7 in the Supplement).

#### Co-Viewing

A total of 12 studies (6083 participants) produced a significant and positive combined effect size $r = 0.16$ (95% CI, 0.07-0.24; Figure 3). No publication bias was detected (eFigure 4 in the Supplement). Two outliers were identified; however, there was evidence of significant between-study heterogeneity with ($Q_B = 152.91$; $P < .001$; $I^2 = 92.81$) and without ($Q_B = 66.21$; $P < .001$; $I^2 = 86.41$) the outlying studies. Results of all moderator analyses can be found in eTable 8 in the Supplement. Child sex emerged as a significant moderator (eFigure 5 in the Supplement) for every 2.5% unit increase in the percentage of boys in a sample, the effect size increased by 0.03 (95% CI, 0.01-0.05).

### Meta-analytic Results for Age at Onset

A total of 4 studies (457 participants) produced a significant pooled effect size of $r = 0.17$ (95% CI, 0.07-0.27; **Figure 4**), Table. Characteristics of All Studies Included in the Meta-analysis

| Source | No. | Age, Mean, mo | | % Male | SES | Study design | Assessment | | Screen | | Language type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Screens | Language | | | | Language | Screen | Use variable | Type | |
| Allen et al,[41] 1992 | 53 | 127.0 | 127.0 | 60.0 | D | CS | SA | Dr | ST | TV | R |
| Alloway et al,[42] 2014 | 30 | 36.0 | 36.0 | 57.0 | D | CS | SA | Q | ST, ED | TV | R |
| Arraf et al,[43] 1990 | 173 | 45.0 | 45.0 | 50.0 | M/H | CS | SA | Dr | ST, ED, CoV | TV | G |
| Barr et al,[44] 2010 | 53 | 15.8 | 49.9 | 46.7 | M/H | L | SA | Dr | ST, ED | TV | R |
| Bittman et al,[45] 2011 | | | | | | | | | | | |
| Cohort 1 | 2335 | 30.0 | 54.0 | 50.0 | D | L | SA | Dr | ST, BG, CoV | TV, C | R |
| Cohort 2 | 2233 | 84.0 | 102.0 | 50.0 | D | L | SA | Dr | ST | TV | R |
| Blankson et al,[15] 2015 | 228 | 36.0 | 60.0 | 48.0 | M/H | L | SA | Q | ST | TV | R |
| Byeon and Hong et al,[46] 2015 | 1778 | 27.0 | 27.0 | 51.3 | D | CS | SA | Q | ST | TV | G |
| Castles et al,[47] 2013 | 1539 | 48.0 | 48.0 | 50.6 | D | CS | SA | Q | ST | TV, C | G |
| Chonchaiya and Pruksananonda et al,[6] 2008 | 166 | 31.5 | 31.5 | 63.0 | NS | CS | SA | I | ST, CoV, On | TV | G |
| Christakis et al,[3] 2009 | 329 | 18.6 | 22.7 | 51.0 | D | L | O | Dr | BG | TV | G |
| Duch et al,[48] 2013 | 73 | 21.1 | 21.1 | 38.1 | Low | CS | SA | Dr | ST | TV, C, M | G |
| Hudon et al,[49] 2013 | 84 | 21.3 | 21.3 | 43.5 | NS | CS | SA | Q | ST, ED, BG, CoV, On | TV | E |
| Lee et al,[7] 2017 | 1870 | 36.0 | 36.0 | 51.1 | D | CS | SA | I | ST, CoV | TV | G |
| Levin et al,[50] 1978 | 60 | 48.0 | 48.0 | 50.0 | M/H | CS | SA | Q | ST | TV | R |
| Lin et al,[51] 2015 | 150 | 24.8 | 24.8 | 72.0 | NS | CS | SA | Q | ST | TV | G |
| Linebarger and Walker,[13] 2005 | 51 | 12.0 | 30.0 | 45.1 | D | L | SA | Dr | ST | TV | E |
| Linebarger et al,[52] 2013 | 121 | 68.4 | 68.4 | 45.0 | Low | CS | SA | Dr | ST, CoV | TV | G |
| Masur et al,[53] 2016 | 25 | 13.0 | 17.0 | 44.0 | M/H | L | SA | Q | BG | TV | E |
| McKean et al,[54] 2015 | 763 | 48 | 84.0 | 50.5 | Low | L | SA | Q | ST | TV | G |
| Mendelsohn et al,[55] 2010 | 253 | 6.0 | 14.0 | 46.6 | Low | L | SA | I | ST, CoV | TV, VG | G |
| Moon et al,[56] 2018 | 39 | 48.0 | 48.0 | 53.8 | NS | CS | SA | Q | ST | M | G |
| Nelson et al,[57] 1973 | 19 | 12.0 | 24.0 | 38.9 | NS | L | O | Dr | ST, BG | TV | E |
| Pagani et al,[58] 2013 | 1999 | 29.0 | 60.0 | 50.0 | NS | L | SA | I | ST | TV | R |
| Patterson et al,[59] 2002 | 64 | 23.7 | 23.7 | 50.0 | NS | CS | SA | I | ST | TV | E |
| Rice et al,[10] 1990 | | | | | | | | | | | |
| Cohort 1 | 115 | 36.0 | 60.0 | 50.0 | NS | L | SA | Dr | ED, CoV | TV | R |
| Cohort 2 | 118 | 60.0 | 84.0 | 50.0 | NS | L | SA | Dr | ED, CoV | TV | R |
| Richert et al,[60] 2010 | 88 | 72.7 | 72.7 | 54.1 | NS | CS | SA | Dr | ST, On | TV | G |
| Rosenqvist et al,[61] 2016 | 381 | 102.0 | 102.0 | 50.0 | NS | CS | SA | Q | ST | TV, C | G |
| Ruangdaraganon et al,[8] 2009 | 203 | 6.0 | 24.0 | 53.0 | NS | L | SA | Q | ST | TV | G |
| Schmidt et al,[62] 2009 | 872 | 6.0 | 36.0 | 49.7 | D | L | SA | Q | ST | TV | R |
| Selnow and Bettinghaus,[63] 1982 | 93 | 48.0 | 48.0 | 54.8 | M/H | CS | SA | Dr | ST, ED | TV | R |
| Taylor et al,[64] 2018 | | | | | | | | | | | |
| Cohort 1 | 51 | 12.0 | 12.0 | 46.6 | NS | CS | SA | Q | ST | TV, C, M, VG | G |
| Cohort 2 | 39 | 27.5 | 27.5 | 46.6 | NS | CS | SA | Q | ST | TV, C, M, VG, | G |
| Tomopoulos et al,[65] 2010 | 259 | 6.0 | 14.0 | 47.1 | Low | L | SA | I | ST, ED | TV, VG | G |
| van den Heuvel et al,[66] 2019 | 893 | 18.7 | 18.7 | 54.1 | D | CS | SA | Q | ST | M | E |

(continued)

Table. Characteristics of All Studies Included in the Meta-analysis (continued)

| Source | No. | Age, Mean, mo | | % Male | SES | Study design | Assessment | | Screen | | Language type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Screens | Language | | | | Language | Screen | Use variable | Type | |
| Wright et al,[67] 2001 | | | | | | | | | | | |
| Cohort 1 | 90 | 24.0 | 60.0 | 50.0 | D | L | SA | I | ST, ED | TV | R |
| Cohort 2 | 92 | 48.0 | 84.0 | 50.0 | D | L | SA | I | ST, ED | TV | R |
| Yang et al,[14] 2017 | 119 | 55.7 | 55.7 | 49.0 | M/H | CS | SA | Q | ST, ED, CoV, On | TV, M, C | R |
| Zimmerman et al,[5] 2007 | | | | | | | | | | | |
| Cohort 1 | 345 | 21.0 | 21.0 | 50.0 | M/H | CS | SA | I | ST, ED, CoV | TV | G |
| Cohort 2 | 384 | 12.0 | 12.0 | 50.0 | M/H | CS | SA | I | ST, ED, CoV | TV | G |
| Zimmerman et al,[68] 2009 | 275 | 21.0 | 21.0 | 49.0 | M/H | CS | SA | O | ST | TV | G |

Abbreviations: BG, background television; C, computer; CoV, co-viewing; CS, cross-sectional; D, diverse incomes; Dr, screen time diary; E, expressive language; ED, educational programming; G, general language; I, interview; L, longitudinal; M, mobile; M/H, middle/high incomes; NS, income not specified; O, observer rating; On, age at onset of screens; Q, screen time use questionnaire; R, receptive language; SA, structured assessment; SES, socioeconomic status; ST, screen time; TV, television or DVD; VG, video games.

suggesting that as the age at onset of screen use increased, stronger language skills were observed. No publication bias (eFigure 6 in the Supplement) or outliers were detected. There was no evidence of heterogeneity of effect sizes ($Q_B$ = 3.36; $P$ = .34; $I^2$ = 10.59); thus, moderator analyses were not explored.

## Discussion

To address the ongoing debate as to the risks and benefits of screen use on child language, results from this series of meta-analyses suggest that greater quantity of screen use (screen time and background television) was associated with lower child language, while better quality of screen use (educational and co-viewing) was positively associated with child language skills. Age at onset of screen use was also positively associated with language, suggesting that language benefits of screen exposure were more likely to be later vs earlier in childhood. These results are consistent with current pediatric guidelines that suggest no screen exposure prior to age 18 months and, for those older than 18 months, to limit the duration of screen exposure. Moreover, caregivers should ensure that programing is high quality and, when possible, to co-view with the child.

An important caveat prior to a fuller discussion of the meta-analytic findings is that the magnitude of the associations observed were small to moderate.[37] Moreover, given the multi-deterministic nature of child development, these findings should be placed in the context of other important predictors of child language. For example, a 2019 meta-analysis[37] demonstrated a moderate to large effect size between sensitive parenting behavior and child language ($r$ = 0.27; 95% CI, 0.21-0.33).[69] In addition, many other environmental factors have been associated with child language, for example preterm birth,[70] socioeconomic status,[71] and number of words spoken by caregivers.[72,73] Thus, child development is multifactorial, and screen use represents one of many predictors in the child's developmental ecology.[74] Nevertheless, small effect sizes can have large public health implications, especially when the exposure, as in this case, is ubiquitous and, in principal, easy to moderate.

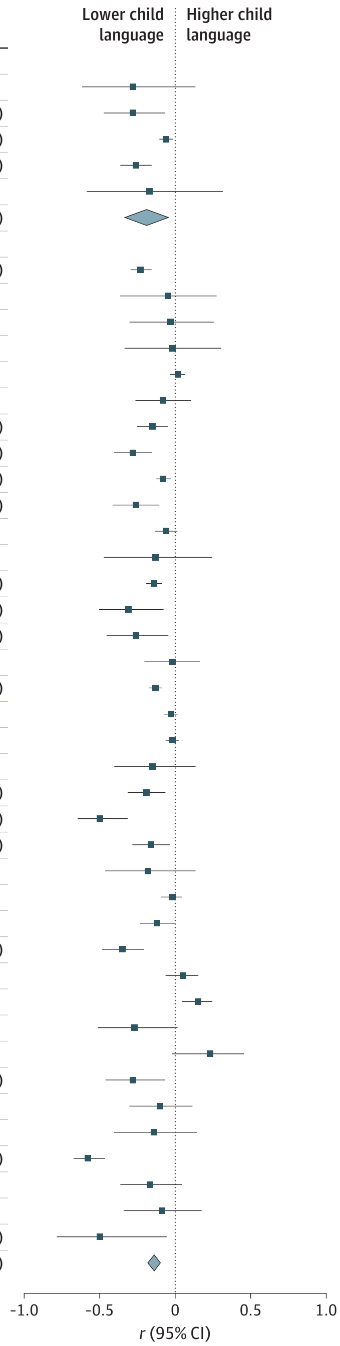
Greater quantity of screen use was associated with lower language skills in children. Experimental studies have demonstrated that the ability to apply information from screens to real life may be restricted in young children, known as a transfer deficit.[75] Screen time viewing can also displace a variety of missed opportunities to practice developmental milestones, such as language and motor skills.[9] That is, screen time may displace time spent learning, for example, to walk, talk, and draw. Moreover, screens can limit or hinder important caregiver-child interactions that are critical for enhancing child language,[55,76,77] especially in vulnerable groups.[70]

With regard to quality of programming, the meta-analytic results suggest that educational programs may be beneficial for child language. It is important to note that the quality of educational programs varied from study to study (eTable 1 in the Supplement) and therefore, caution should be exercised in interpreting that all educational programs are beneficial to children. Nonetheless, it is possible that educational programs geared toward younger children tend to include a coherent and integrative narrative, as well as age-appropriate language, which can assist with learning.[13] Educational programs that label objects, speak directly to the child, and provide opportunities to respond verbally (eg, *Sesame Street* and *Dora the Explorer*) may be particularly beneficial.[13] The auditory and visual simulation of educational programs is also often appropriately paced to the child's developmental needs, which may enhance learning.[78]

Exposure to co-viewing was also found to be positively associated with child language skills. Previous reports suggest that caregivers co-view approximately 50% of the time the child is watching programming (although this number may be on the decline, with solitary tablet use on the incline).[79] During this time, caregivers may use co-viewing as an opportunity for linguistic interaction, such as labeling content and asking questions.[80] Exposure to caregiver linguistic input, including the quantity and quality of speech,[72] can promote learn-

Figure 2. Forest Plots of the Effect Sizes for Each Study Included in the Meta-analyses on Quantity of Screen Use (Screen Time and Background Television) and Child Language

| Source | r (95% CI) | Weight, % |
|---|---|---|
| Background TV | | |
| Masur et al,[53] 2016 | −0.28 (−0.61 to 0.13) | 9.33 |
| Hudon et al,[49] 2013 | −0.28 (−0.47 to −0.07) | 20.08 |
| Bittman et al,[45] 2011 | −0.06 (−0.10 to −0.02) | 33.90 |
| Christakis et al,[3] 2009 | −0.26 (−0.36 to −0.16) | 29.37 |
| Nelson et al,[57] 1973 | −0.17 (−0.58 to 0.31) | 7.32 |
| Overall | −0.19 (−0.33 to −0.05) | |
| Duration of screen time | | |
| van den Heuvel et al,[66] 2019 | −0.23 (−0.29 to −0.16) | 3.90 |
| Moon et al,[56] 2018 | −0.05 (−0.36 to 0.27) | 1.25 |
| Taylor et al cohort 1,[64] 2018 | −0.03 (−0.30 to 0.25) | 1.52 |
| Taylor et al cohort 2,[64] 2018 | −0.02 (−0.33 to 0.30) | 1.25 |
| Lee et al,[7] 2017 | 0.02 (−0.03 to 0.06) | 4.09 |
| Yang et al,[14] 2017 | −0.08 (−0.26 to 0.10) | 2.44 |
| Rosenqvist et al,[61] 2016 | −0.15 (−0.25 to −0.05) | 3.47 |
| Blankson et al,[15] 2015 | −0.28 (−0.40 to −0.16) | 3.08 |
| Byeon et al,[46] 2015 | −0.08 (−0.12 to −0.03) | 4.08 |
| Lin et al,[51] 2015 | −0.26 (−0.41 to −0.11) | 2.68 |
| McKean et al,[54] 2015 | −0.06 (−0.13 to 0.01) | 3.84 |
| Alloway et al,[42] 2014 | −0.13 (−0.47 to 0.24) | 1.01 |
| Castles et al,[47] 2013 | −0.14 (−0.19 to −0.09) | 4.05 |
| Duch et al,[45] 2013 | −0.31 (−0.50 to −0.08) | 1.90 |
| Hudon et al,[49] 2013 | −0.26 (−0.45 to −0.05) | 2.07 |
| Linebarger et al,[52] 2013 | −0.02 (−0.20 to 0.16) | 2.46 |
| Pagani et al,[58] 2013 | −0.13 (−0.17 to −0.09) | 4.10 |
| Bittman et al cohort 1,[45] 2011 | −0.03 (−0.07 to 0.01) | 4.12 |
| Bittman et al cohort 2,[45] 2011 | −0.02 (−0.06 to 0.02) | 4.12 |
| Barr et al,[44] 2010 | −0.15 (−0.40 to 0.13) | 1.56 |
| Mendelsohn et al,[55] 2010 | −0.19 (−0.31 to −0.07) | 3.17 |
| Richert et al,[60] 2010 | −0.50 (−0.64 to −0.32) | 2.11 |
| Tomopoulos et al,[65] 2010 | −0.16 (−0.28 to −0.04) | 3.19 |
| Ruangdaraganon et al,[8] 2009 | −0.18 (−0.46 to 0.13) | 1.30 |
| Schmidt et al,[62] 2009 | −0.02 (−0.09 to 0.04) | 3.89 |
| Zimmerman et al,[68] 2009 | −0.12 (−0.23 to 0.00) | 3.24 |
| Chonchaiya et al,[6] 2008 | −0.35 (−0.48 to −0.21) | 2.78 |
| Zimmerman et al cohort 1,[5] 2007 | 0.05 (−0.06 to 0.15) | 3.41 |
| Zimmerman et al cohort 2,[5] 2007 | 0.15 (0.05 to 0.24) | 3.48 |
| Linebarger et al,[13] 2005 | −0.27 (−0.51 to 0.01) | 1.52 |
| Patterson et al,[59] 2002 | 0.23 (−0.02 to 0.45) | 1.76 |
| Wright et al cohort 1,[67] 2001 | −0.28 (−0.46 to −0.07) | 2.13 |
| Wright et al cohort 2,[67] 2001 | −0.10 (−0.30 to 0.11) | 2.16 |
| Allen et al,[41] 1992 | −0.14 (−0.40 to 0.14) | 1.56 |
| Arraf et al,[43] 1990 | −0.58 (−0.67 to −0.47) | 2.83 |
| Selnow et al,[63] 1982 | −0.17 (−0.36 to 0.04) | 2.17 |
| Levin et al,[50] 1978 | −0.09 (−0.34 to 0.17) | 1.69 |
| Nelson et al,[57] 1973 | −0.50 (−0.78 to −0.06) | 0.66 |
| Overall | −0.14 (−0.18 to −0.10) | |



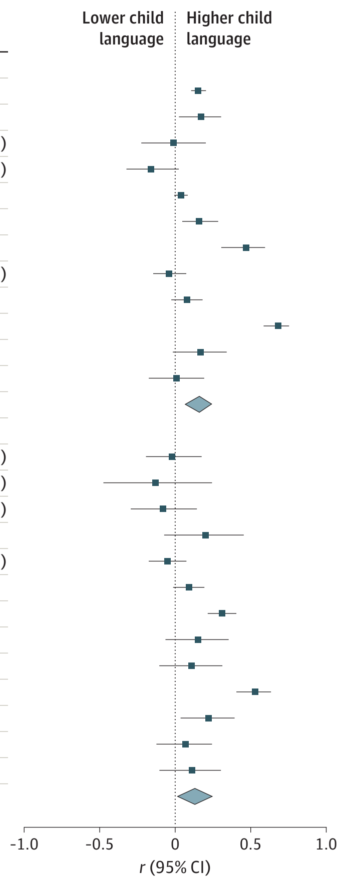

Contributing studies are sorted in reverse chronological order. Square data markers represent effect size estimates (*r*), with size of the markers corresponding to 95% CIs and diamond data markers representing the overall effect size based on included studies.

ing for children.[72,81] Caregivers may also scaffold screen content or supplement screen viewing with live interactions, which in turn can help children effectively apply learning concepts.[82] It is possible that when co-viewing screens, caregivers are more attuned to the quality of programming being viewed, and therefore, children are more likely to watch programs intended for their age group, which may in turn increase comprehension and language learning.[49] A greater understanding of these factors will help appropriately target screen time interventions. Also, it should be noted that emerging evidence suggests that interactive screens may diminish rather than enhance opportunities for parent-child interactions.[83]

The finding that boys in particular benefit from co-viewing is somewhat surprising given the preexisting sex differences in early language acquisition, with girls slightly outperforming boys in this domain at a young age.[84,85] However, given this disparity, boys may receive more benefits of linguistic engagement with a caregiver when viewing screens than

Figure 3. Forest Plots of the Effect Sizes for Each Study Included in the Meta-analyses on Quality of Screen Use (Educational Programming and Co-viewing) and Child Language

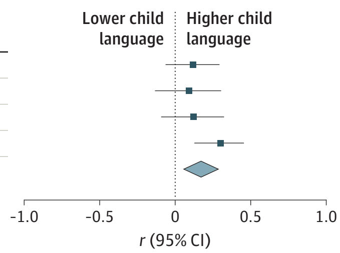
| Source | r (95% CI) | Weight, % |
|---|---|---|
| **Co-viewing** | | |
| Lee et al,[7] 2017 | 0.15 (0.11 to 0.20) | 9.70 |
| Yang et al,[14] 2017 | 0.17 (0.03 to 0.30) | 8.38 |
| Hudon et al,[49] 2013 | −0.01 (−0.22 to 0.20) | 6.92 |
| Linebarger et al,[52] 2013 | −0.16 (−0.32 to 0.02) | 7.62 |
| Bittman et al,[45] 2011 | 0.04 (0.00 to 0.08) | 9.74 |
| Mendelsohn et al,[55] 2010 | 0.16 (0.04 to 0.28) | 8.67 |
| Chonchaiya et al,[6] 2008 | 0.47 (0.31 to 0.59) | 7.65 |
| Zimmerman et al cohort 1,[5] 2007 | −0.04 (−0.14 to 0.07) | 8.96 |
| Zimmerman et al cohort 2,[5] 2007 | 0.08 (−0.02 to 0.18) | 9.05 |
| Arraf et al,[43] 1991 | 0.68 (0.59 to 0.75) | 8.19 |
| Rice et al cohort 1,[10] 1990 | 0.17 (−0.01 to 0.34) | 7.53 |
| Rice et al cohort 2,[10] 1990 | 0.01 (−0.17 to 0.19) | 7.57 |
| Overall | 0.16 (0.07 to 0.24) | |
| **Educational** | | |
| Yang et al,[14] 2017 | −0.02 (−0.19 to 0.17) | 7.92 |
| Alloway et al,[42] 2014 | −0.13 (−0.47 to 0.24) | 4.67 |
| Hudon et al,[49] 2013 | −0.08 (−0.29 to 0.14) | 7.26 |
| Barr et al,[44] 2010 | 0.20 (−0.07 to 0.45) | 6.19 |
| Tomopoulos et al,[65] 2010 | −0.05 (−0.17 to 0.07) | 8.95 |
| Zimmerman et al cohort 1,[5] 2007 | 0.09 (−0.01 to 0.19) | 9.22 |
| Zimmerman et al cohort 2,[5] 2007 | 0.31 (0.22 to 0.40) | 9.29 |
| Wright et al a,[67] 2001 | 0.15 (−0.06 to 0.35) | 7.40 |
| Wright et al b,[67] 2001 | 0.11 (−0.10 to 0.31) | 7.40 |
| Arraf et al,[43] 1990 | 0.53 (0.41 to 0.63) | 8.48 |
| Rice et al cohort 1,[10] 1990 | 0.22 (0.04 to 0.39) | 7.86 |
| Rice et al cohort 2,[10] 1990 | 0.07 (−0.12 to 0.24) | 7.90 |
| Selnow et al,[63] 1982 | 0.11 (−0.10 to 0.30) | 7.46 |
| Overall | 0.13 (0.02 to 0.24) | |




Contributing studies are sorted in reverse chronological order. Square data markers represent effect size estimates (*r*), with size of the markers corresponding to 95% CIs and diamond data markers representing the overall effect size based on included studies.

Figure 4. Forest Plot of the Effect Sizes for Each Study Included in the Meta-analysis on Age at Onset of Screen Exposure and Child Language

| Source | r (95% CI) | Weight, % |
|---|---|---|
| Yang et al,[14] 2017 | 0.12 (−0.06 to 0.29) | 28.59 |
| Hudon et al,[49] 2013 | 0.09 (−0.13 to 0.30) | 20.72 |
| Richert et al,[60] 2010 | 0.12 (−0.09 to 0.32) | 21.65 |
| Chonchaiya et al,[6] 2008 | 0.30 (0.13 to 0.45) | 29.04 |
| Overall | 0.17 (0.07 to 0.27) | |




Contributing studies are sorted in reverse chronological order. Square data markers represent effect size estimates (*r*), with size of the markers corresponding to 95% CIs and diamond data markers representing the overall effect size based on included studies.

girls, who may have more progression in their language skills. Indeed, studies have found that when learning language, verbal encouragement and attention from mothers is particularly important for boys' language development.[86]

Although better quality of screen exposure was associated with language skills, too much screen exposure, introduced too early in development, is associated with lower language skills. Thus, consistent with the pediatric guidelines, high-quality screen programming should be used in moderation and should not replace important individual or family activities and health behaviors, such as device-free family interactions, adequate sleep, book reading, and active play. Taking into account the results of this study, as well as research suggesting that excessive screen use leads to delayed learning and achievement of developmental milestones[4] and is associated with behavioral difficulties, shortened or disrupted sleep, poor school readiness, and reduced physical activity,[5,48,78,87-90] it is important for clinicians to review media use in the home with children and families.[21] Moreover, because meta-analytic evidence suggests that merely delivering a message to reduce screen time is ineffective,[91] further steps include directing caregivers to online personalized family media planning,[92] encouraging parent-child co-viewing of educational programming[55] to maximize its potential benefits, and supporting caregivers to prioritize face-to-face interactions with children that include stimulating exposure to language and reinforcement of communicative engagement.[70]

### Limitations

Several limitations of this study should be noted. First, results are correlational, not causal. Second, in some cases, pooled effect sizes are based on small sample sizes, which may limit power in detecting moderator effects. Third, in all included studies, the method for measuring screen use (ie, duration, co-viewing, and/or educational) was parent report, which introduces potential bias and underreporting.[93] Fourth, although we included all studies amassed to date, most studies in this meta-analysis are prior to the mass movement toward handheld devices. Co-viewing may be less likely with handheld devices compared with television[1,94] and educational apps may begin to replace educational programs on television. Thus, technology is vastly outpacing research, and a clear understanding of how handheld or mobile devices are affecting child development and health is particularly needed. Finally, approximately half of the studies in our meta-analysis did not present adjusted effect sizes. It will be important in future research to include demographic covariates as well as covariates, such as cognitive stimulation, parent sensitivity, and child care quality, when evaluating the nature of the association between screen use and child outcomes.

## Conclusions

Young children are growing up with increasing exposure and access to digital media and screens.[1,2] Findings from this study suggest that greater quantity of screen use (ie, duration of use and background television) is associated with lower language skills. Better quality of screen exposure in older children (ie, educational and co-viewing) appears to be beneficial for child language; however, it remains that screens should continue to be used in moderation. It will be important in future research to identify which components of screen time viewing are most beneficial vs detrimental for child language (eg, interactive apps, computer use, or video streaming)[83] and to examine the potential role of co-viewing, media multitasking, and household media rules on children's outcomes.

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*Concept and design:* Madigan, Anhorn, Christakis.
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