Longitudinal Associations Between Screen Use and Reading in Preschool-Aged Children

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abstract

BACKGROUND AND OBJECTIVES: The home literacy environment has been identified as a key predictor of children's language, school readiness, academic achievement, and behavioral outcomes. With the increased accessibility and consumption of digital media, it is important to understand whether screen use impacts off-line enrichment activities such as reading or whether reading activities offset screen use. Using a prospective birth cohort, we examined reading and screen use at 24, 36, and 60 months to elucidate the directional association between screen use and reading over time.

METHODS: This study included data from 2440 mothers and children in Calgary, Alberta, drawn from the All Our Families cohort. Children's screen use and reading activities were assessed via maternal report at age 24, 36, and 60 months. Sociodemographic covariates were also collected.

RESULTS: Using a random-intercepts cross-lagged panel model, which statistically controls for individual-level confounds, this study revealed that greater screen use at 24 months was associated with lower reading at 36 months (β = −.08; 95% confidence interval: −0.13 to −0.02). In turn, lower reading at 36 months was associated with greater screen use at 60 months (β = −.11; 95% confidence interval: −0.19 to −0.02). Covariates did not modify the associations.

CONCLUSIONS: A reciprocal relationship between screen use and reading was identified. Early screen use was associated with lower reading activities, resulting in greater screen use at later ages. Findings emphasize the need for practitioners and educators to discuss screen use guidelines and encourage families to engage in device-free activities to foster early literacy exposure.

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WHAT'S KNOWN ON THIS SUBJECT: Book reading is a critical element of the home environment that promotes school readiness and academic achievement. With increasing use of media devices, longitudinal research is needed to determine if screen use is interfering with off-line activities such as reading.

WHAT THIS STUDY ADDS: Findings support a dynamic relationship whereby screen use at 24 months leads to lower reading at 36 months, which in turn leads to greater screen use at 60 months. Families should be encouraged to engage in device-free time.

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ARTICLE

Children enter school with varying literacy skills, and these differences tend to get larger over time without intervention.[1,2] The home environment, including parent-child shared print book reading and language exposure, has been shown to have a large impact on children's later academic achievment.[3] In addition, shared book reading promotes important parent-child engagement during sensitive periods of development.[4] As a result, there have been long-standing efforts to identify factors that may influence the home literacy environment.[5–7]

With the increased use and accessibility of media devices,[8] screen use is becoming a consistent part of children's day-to-day lives. According to the displacement hypothesis,[9] when children are watching screens, they are less likely to spend time practicing skills important for learning and development.[10] As such, screen use may be influencing the home learning environment, specifically engagement in off-line enrichment activities such as reading print books,[11] and displacement may be one mechanism to explain the relation between screen time and delays in developmental skill acquisition. Although it is possible that screen use interrupts enriching off-line activities such as print book reading,[9,12] it is also possible that early reading activities may offset later screen use. However, to test this hypothesis, longitudinal data with repeated measurement are needed to examine directional associations between screen use and reading.

The primary aim of this study was to explicitly test what comes first: higher screen use or lower reading activities? In a sample of 2440 families, using a 3-wave (24, 36, and 60 months) random intercept cross-lagged panel model (RI-CLPM),[13] we predict that higher screen use will relate to lower reading activities at later time points. The RI-CLPM is considered to be the most robust method for addressing directionality in observational studies by statistically controlling for individual-level confounds, such as stable family-level stressors.[13] The secondary aim of this study was to explore the extent to which the longitudinal associations between screen use and reading varied on the basis of sociodemographic covariates. Implications of these findings could inform pediatricians, health care practitioners, child care providers, educators and policymakers seeking to guide parents on appropriate recommendations for screen exposure and off-line activities such as reading during the sensitive period of early childhood.

METHODS

Study Design and Population

Participants were from All Our Families, a pregnancy cohort of 3388 mothers and children from Calgary, Canada.[14,15] Women were recruited between August 2008 and December 2010 through primary health care offices, community advertising, and laboratories. Inclusion criteria were (1) age ≥18 years, (2) fluent in English, (3) gestational age <25 weeks, and (4) receiving community-based prenatal care. Mothers were followed-up at <25 weeks' gestation and at 4, 12, 24, 36, and 60 months' postpartum. The 24-, 36-, and 60-month time points were the focus of this analysis because screen use and reading variables were both collected. A detailed description of the study sample can be found in Table 1. All procedures were approved by the institutional ethics board.

Measures

Screen Use

When children were aged 24, 36, and 60 months, mothers reported the range of time their child spent using electronic devices (ie, watching television programs; watching movies, videos, or stories on a videocassette recorder or digital video disk player; and using a computer, gaming system, or other screen-based device) on a typical weekday and typical weekend day. A weighted average across week and weekend days and electronic devices was calculated to yield screen use in hours per week. At each time point, outliers >4 SDs from the mean were winsorized[16] (n = 8 at 24 months, n = 16 at 36 months, and n = 7 at 60 months).

Reading Activities

When children were aged 24, 36, and 60 months, mothers reported the range of time their child spent in reading activities using a 4-point response scale. At 24 months, mothers were asked, "Do you or another adult of the household read to your child or show him/her picture books?" with response options ranging from (1) never to (4) daily. At 36 months, mothers were asked, "How many minutes each day do you spend sharing books with your child?" with response options ranging from (1) 0 to 10 minutes to (4) ≥30 minutes. At 60 months, mothers were asked, "How many hours per day does your child spend doing the following activities outside of child care, preschool, or school: Read or look at books?" on a typical weekday and weekend day. Response options ranged from (1) none or 0 minutes to (4) ≥3 hours. At 60 months, a weighted average across week and weekend days was calculated to yield reading in hours per day, with a range from (1) none or 0 minutes to (4) ≥3 hours. The reading items were designed to reflect the natural progression of reading activities across early childhood. Results from this study suggest consistency in this measurement method over time (24–36 months [β = .23; 95% confidence interval (CI): .18 to .29]; 36–60 months [β = .24; 95% CI: .18 to .29]).

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TABLE 1 Sample Demographics and Study Characteristics

Characteristic	Value
Maternal education, *n* (%)	
Less than high school	40 (1.6)
Graduated high school	104 (4.3)
Some college or trade school or university	233 (9.6)
Graduated college or trade school or university	1265 (51.9)
Some graduate school	42 (1.7)
Completed graduate school	307 (12.6)
Missing	449 (18.3)
Household income, CAD $, *n* (%)	
≤29 999	35 (1.4)
30 000–39 999	43 (1.8)
40 000–49 999	50 (2.1)
50 000–59 999	98 (4.0)
60 000–69 999	76 (3.1)
70 000–79 999	122 (5.0)
80 000–89 999	140 (5.7)
90 000–99 999	147 (6.0)
100 000–124 999	358 (14.7)
125 000–149 999	258 (10.6)
≥150 000	644 (26.4)
Missing	469 (19.1)
Maternal race and/or ethnicity, *n* (%)	
White	1993 (81.7)
Black and/or African American	29 (1.2)
Indigenous	12 (0.5)
Asian	254 (10.4)
Latin American	37 (1.5)
Multiracial or other	100 (4.1)
Missing	15 (0.6)
Child sex, *n* (%)	
Female	937 (38.4)
Male	1018 (41.7)
Missing	485 (19.9)
Nonparental child care or day care before 60 mo, *n* (%)	
Yes	1433 (58.8)
No	533 (21.9)
Missing	474 (19.4)
Maternal screen use at 24 mo, *n* (%)	
None	111 (4.6)
<1 h	441 (18.1)
1–<3 h	859 (35.3)
3–<5 h	149 (6.1)
5–<7 h	24 (1.0)
≥7 h	10 (0.4)
Missing	846 (34.6)
Maternal reading at 24 mo, *n* (%)	
None	199 (8.2)
<1 h	879 (36.1)
1–<3 h	440 (18.1)
3–<5 h	57 (2.3)
5–<7 h	13 (0.5)
≥7 h	6 (0.2)
Missing	846 (34.6)
Attended the library at 24 mo, *n* (%)	
Yes	961 (39.5)
No	635 (26.0)
Missing	844 (34.5)
Problem behavior (BITSEA) at 24 mo, *n* (%)	
At risk	236 (9.7)
Normative	1344 (55.1)
Missing	860 (35.2)

Covariates

Child sex (1 [female]; 0 [male]), household income (reported in increments of $10 000 Canadian dollars [CAD]: 1 [≤$29 999]; 11 [≥$150 000]), and maternal education (1 [less than a high school education]; 6 [completed graduate school]) were maternal self-report. At 24 months, maternal screen use and maternal reading were measured with single self-report items asking the amount of time mothers spend watching television or reading, respectively, on a typical weekday (1 [none]; 6 [≥7 hours per day]). Attending the library (eg, story time, borrowing books or videos, etc) in the past year (yes [1]; no [0]) was also measured with a single self-report item. Mothers completed the Brief Infant-Toddler Social and Emotional Assessment (BITSEA) to identify child behavior problems (eg, aggression, defiance, over-activity, negative emotionality, anxiety, and withdrawal). By using the BITSEA standardized scoring cutoffs, children were categorized with possible behavioral problems if they scored in the ≥75th percentile on the scale.[17] At 60 months, mothers responded to "has your child been in nonparental child care or day care on a regular basis before this year?" (0 [no]; 1 [yes]).

Statistical Analyses

The longitudinal associations between hours of screen use and reading activities were examined by using an RI-CLPM.[13] The RI-CLPM statistically distinguishes variance at the temporal level (ie, within-person or time-varying) from variance at the individual level (ie, between-person or stable) and, therefore, constitutes a multilevel approach accounting for repeated measurements that are nested within individuals. An important advantage of the RI-CLPM over the common cross-lagged panel model is that RI-CLPM controls for

TABLE 1 Continued

Characteristic	Value
Weekly hours of screen use at 24 mo, mean (SD)	17.07 (11.82)
Weekly hours of screen use at 36 mo, mean (SD)	24.90 (12.50)
Weekly hours of screen use at 60 mo, mean (SD)	10.84 (5.29)
Reading activities at 24 mo, mean (SD)	3.92 (0.29)
Reading activities at 36 mo, mean (SD)	2.61 (0.94)
Reading activities at 60 mo, mean (SD)	2.48 (0.52)

stable individuals' differences (ie, between-person and time-invariant effects, such as stable family-level stressors) in reading activities and screen use, allowing for greater insight into how the two central constructs in the model (ie, screen use and reading activities) are linked at an intraindividual (ie, within-person and time-varying) level. This approach has been shown to reduce bias in directional estimates and more closely approximate causal relationships.[18]

First, the standard RI-CLPM was estimated. In the RI-CLPM, between-person (stable) factors were extracted from the repeated measures of screen use and reading, and these factors were permitted to covary. The within-person component comprises 3 types of estimates: (1) autoregressions (ie, lags) capture the within-person, rank-order stability in constructs over time; (2) within-time covariances capture the strength and direction of associations between screen use and reading within persons at each time point; and (3) the cross lags capture the longitudinal and directional associations between screen use and reading within persons and are comparable to the proportion of unique variance explained in the outcome that is not shared with any other predictor (ie, a squared semipartial correlation[19,20]; Fig 1). After fitting the standard RI-CLPM, pairwise comparisons were conducted by using post hoc t tests to identify the extent to which the cross-lag estimates varied between different levels of the covariates (measured

at the between-person level). Statistical significance was set at the $P < .05$, 2-tailed level; 95% CIs are reported. All analyses were conducted in Mplus version 8.1.[21]

Missing Data

From the initial pregnancy cohort ($N = 3388$), 95% ($n = 3223$) agreed to be contacted for follow-up research. Of those who agreed to follow-up and were eligible at the time of questionnaire completion, 76% completed the 24-month questionnaire ($n = 1595$), 69% completed the 36-month questionnaire ($n = 1994$), and 71% completed the 60-month questionnaire ($n = 1992$). Attrition rates observed in the current study are similar to other prospective birth cohorts.[22–24] Predictors of dropout are reported elsewhere (younger mothers and lower income).[10] Consistent with other pediatric RI-CLPMs,[10] participants were included ($n = 2440$) if they completed questionnaires for at least 1 time point at either 24, 36, or 60 months. To adjust for missing data, models were run with full-information maximum likelihood estimation.[25,26]

RESULTS

Primary Analyses

The standard RI-CLPM (Fig 1) revealed that the model was a good fit to the observed data on the basis of fit indices ($\chi_1^2 = 0.09$; $P = .768$; root mean square error of approximation = 0.00; 95% CI: 0.00 to 0.04; comparative fit index = 1.00;

standardized root mean square residual = 0.002).

In the time-variant component of the model, statistically significant autocorrelations for every estimated lag indicate substantial within-person stability in constructs over time. That is, on average, children's screen use and reading activities were stable across adjacent time points. As detailed in Fig 1 and Table 2, after accounting for this temporal stability, there was a significant and negative cross lag linking higher levels of screen use at 24 months of age with lower levels of reading activities at 36 months of age ($\beta = -.08$; 95% CI: $-.13$ to $-.02$). The obverse direction of higher levels of reading activities at 24 months being associated with lower exposure to screens at 36 months was not observed ($\beta = -.05$; 95% CI: $-.11$ to .01). At 36 months of age, lower levels of reading activities predicted higher exposure to screen use at 60 months ($\beta = -.11$; 95% CI: $-.19$ to $-.02$). The obverse association was not observed ($\beta = .01$; 95% CI: $-.04$ to .06). Also, within-time covariances were significant at 24 and 36 months but not at 60 months, suggesting that, on average, at the 24- and 36-month study waves, children's screen use was significantly related to children's reading activities ($\beta = -.10$ [95% CI: $-.17$ to $-.04$] and $\beta = -.08$ [95% CI: $-.13$ to $-.03$], respectively).

Taken together, these findings suggest that higher levels of screen use at 24 months of age, relative to a child's average level of screen use (ie, the child's stable mean), was associated with significantly lower levels of reading activities at the next study wave, relative to a child's average level of reading. In addition, lower levels of reading activities at 36 months of age, relative to a child's average level of reading, was associated with significantly higher levels of screen use at 60 months of age, relative to a child's average level of screen use.

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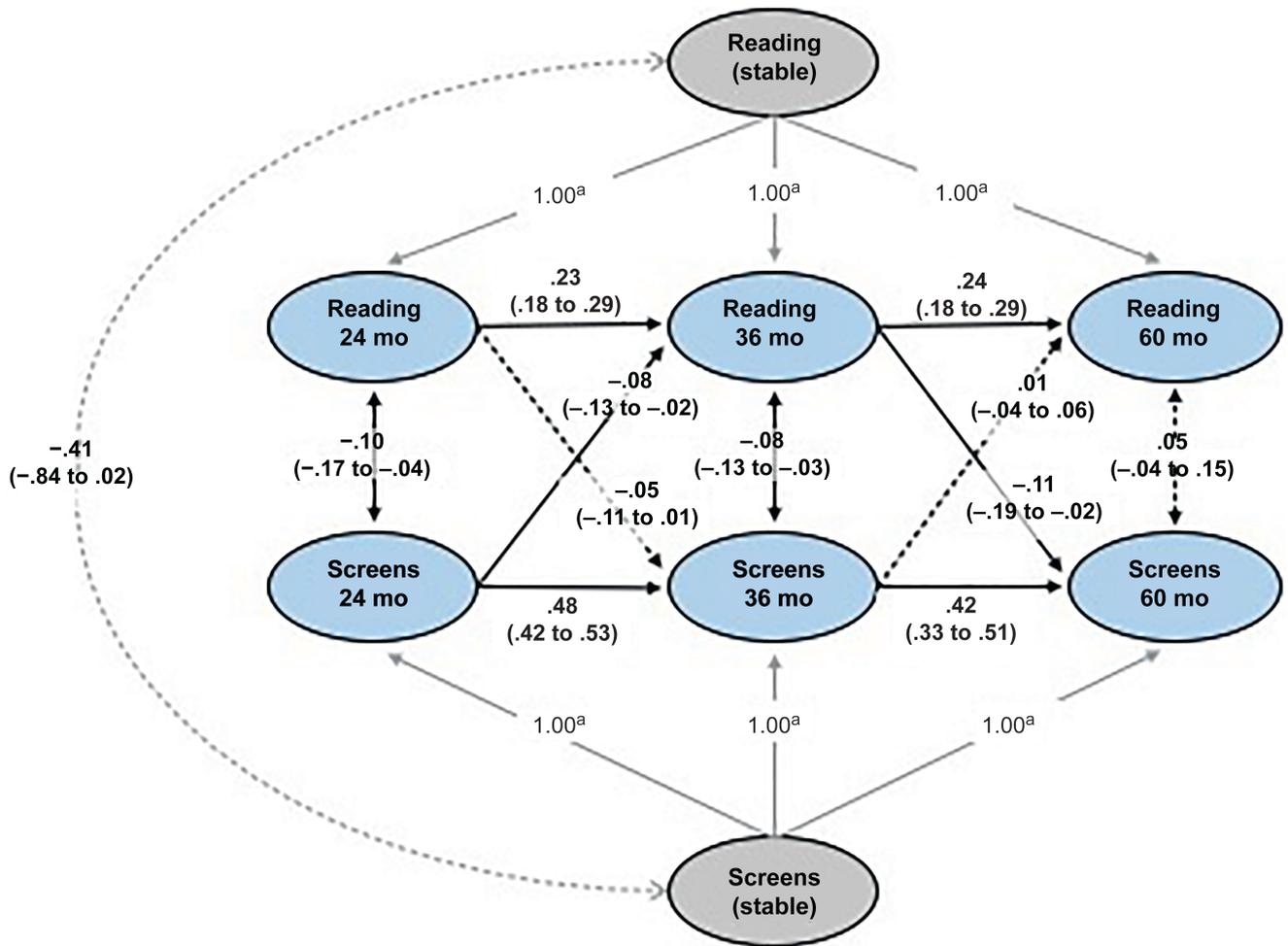
FIGURE 1
The standard RI-CLPM revealing within-person association between screen use and reading from ages 24 to 60 months, controlling for between-person differences. Standardized estimates (β) and 95% CIs are presented. Solid lines represent estimates in which 95% CIs do not include 0. The central, blue-tinted part of the model is the within-person (dynamic) part, and the outer, gray-tinted part of the model is the between-person (stable) component.
[a] Pathways constrained to 1.00 to extract between-person factor (n = 2440).

Secondary Analyses

To determine the extent to which the longitudinal associations between screen use and reading varied on the basis of covariates, the differences in the cross-lagged associations between levels of each study covariate were examined (Table 3). Cross-lagged parameters did not significantly differ on the basis of different levels of the study covariates.

DISCUSSION

With expanding media options and a dynamic digital landscape, screen use is a common household activity for young children.[8] With this change comes growing concern about the role of screen use on the home learning environment, specifically engagement in off-line enrichment activities such as print book reading. This longitudinal, 3-wave study uses repeated measures and a rigorous statistical model that more closely approximate causality to clarify whether screen use interferes with later print book reading or if early reading activities may offset later screen use. Results suggest that higher screen use at 24 months is related to lower reading activities at 36 months, and in turn, lower reading

activities at 36 months is associated with greater screen use at 60 months. The obverse associations (ie, greater reading at 24 months leading to lower screen time at 36 months and, in turn, greater reading at 60 months) were not observed.

A robust body of literature underscores the importance of the early home learning environment to encourage the development of school readiness and literacy skills.[5,23] Consistent with the displacement hypothesis,[9] this study provides support for the notion that screen use may be interfering with reading activities. Indeed, at 24 months, it

Paths	β (95% CI)[a]	B (95% CI)[b]
Autoregressive parameters		
Screen time, mo		
24 → 36	.48 (.42 to .53)[c]	.51 (.43 to .59)[c]
36 → 60	.42 (.33 to .51)[c]	.12 (.07 to .17)[c]
Reading, mo		
24 → 36	.23 (.18 to .29)[c]	.79 (.61 to .97)[c]
36 → 60	.24 (.18 to .29)[c]	.13 (.09 to .16)[c]
Cross-lagged parameters		
Screen time → reading, mo		
24 → 36	−.08 (−.13 to −.02)[c]	−.01 (−.01 to −.002)[c]
36 → 60	.01 (−.04 to .06)	.00 (−.002 to .003)
Reading → screen time, mo		
24 → 36	−.05 (−.11 to .01)	−2.24 (−4.80 to .32)
36 → 60	−.11 (−.19 to −.02)[c]	−.39 (−.67 to −.11)[c]

B, unstandardized β coefficient; β, standardized β coefficient; →, predicting.
[a] Standardized β coefficients represent the SD change in an outcome variable (eg, reading at 36 mo) associated with a 1 SD change in the predictor (eg, screen time at 24 mo).
[b] Unstandardized B coefficients represent the unit change in an outcome variable (eg, 1 level of reading at 36 mo) associated with a unit change in the predictor (eg,1 hour of screen time at 24 mo).
[c] Estimates in which 95% CIs do not include 0.

was observed that greater screen use per week relates to a lower level of reading activities at 36 months. In addition, through interpretation of the unstandardized coefficients, a 10-minute decrease in reading per day at 36 months of age relates to a ~25-minute increase in screen use per week at 60 months of age. These findings highlight a reciprocal process between screen use and reading that unfolds over time, in which screen use negatively influences reading activities and then lowered reading activities lead to greater screen use.

With the increased use and accessibility of media devices, families may turn to electronics to promote reading. Although reading electronic books was not examined herein, researchers have recently found that, for preschool-aged children, parents and children tend to collaborate and verbalize less when reading electronic books in comparison with reading print books.[27,28] Overall, there appears to be less reciprocity and conversational turns (specific elements of the early reading environment known to promote language learning and literacy skills) when using electronic books,[4] and thus encouraging reading activities that involve print books for young children may be advised.

Although past research supports that many factors in the home environment influence screen use[29] and reading activities,[4,5] results from the post hoc analysis of covariates reveal that the sociodemographic variables included in this study did not significantly modify the magnitude of the associations between screen use and reading over time. This finding suggests that sociodemographic factors may be more influential at a between-person level (eg, when predicting overall screen use or reading activities for different children) but may be less impactful at a within-person level (eg, impacting the associations between reading and screen use over time for a specific child).

A number of practice and policy implications arise from this study. Most importantly, this study highlights the need for practitioners, health care workers, parents, policymakers, and educators to promote adherence to screen use guidelines. This is especially important because up to 95% of preschoolers are exceeding the current screen use guidelines[30] of no more than 1 hour of screen time daily.[31] Family media plans[32] can be devised to help families develop healthy media habits. Early discussions with family may be critical because research reveals that once problematic screen use habits are developed, they tend to persist over the early childhood period.[33] On the basis of the within-person stability of shared reading and screen media habits starting at 24 months of age, this study also emphasizes the importance of establishing early reading routines known to be foundational for child development and learning and reaffirms the need for early discussion of reading in pediatric offices. These discussions can focus on the 5 R's[34] of early learning: reading together every day; rhyme and play; developing consistent sleep, eating, reading and play routines; reward with praise; and nurture relationships rich in serve and return interactions. At a policy level, increased access to books, programs designed to help connect at risk-families with literary resources (eg, reach out and read[35]), broader dissemination of screen use guidelines for children aged <5 years, and a combination of early interventions targeted at both reading and screen use habits are needed.

Using a large cohort and a longitudinal research design, as well as a robust statistical method, this study sheds light on the direction of the association between screen use and reading activities across early childhood. However, the findings must be interpreted with the following limitations in mind. First, this study included a predominantly high-income, highly educated sample of participants, which may limit generalizability to other populations. Second, the method of measurement used for screen use did not capture the content (eg, educational programing) or context (eg, solitary versus coviewing) of screen use.

TABLE 3 Differences in the Cross-Lagged Associations Linking Screen Use and Reading, by Covariates

Paths	Difference (95% CI)[a]	
	Income[b]	Education[c]
Screen time → reading, mo		
24 → 36	0.00 (−0.01 to 0.01)	0.01 (−0.004 to 0.02)
36 → 60	0.00 (−0.01 to 0.01)	0.00 (−0.004 to 0.01)
Reading → screen time, mo		
24 → 36	−0.55 (−7.39 to 6.28)	2.33 (−3.32 to 7.97)
36 → 60	−0.66 (−1.64 to 0.32)	−0.11 (−0.83 to 0.62)
	Maternal reading[d]	Maternal screen use[e]
Screen time → reading, mo		
24 → 36	0.00 (−0.01 to 0.01)	0.00 (−0.01 to 0.01)
36 → 60	−0.01 (−0.01 to 0.00)	0.01 (−0.001 to 0.01)
Reading → screen time, mo		
24 → 36	−3.93 (−9.50 to 1.65)	4.44 (−1.39 to 10.27)
36 → 60	0.14 (−0.55 to 0.83)	−0.20 (−1.46 to 1.05)
	Problem behavior[f]	Child sex[g]
Screen time → reading, mo		
24 → 36	0.01 (−0.01 to 0.02)	−0.01 (−0.02 to 0.004)
36 → 60	0.00 (−0.01 to 0.01)	0.00 (−0.001 to 0.005)
Reading → screen time, mo		
24 → 36	1.41 (−5.28 to 8.10)	0.89 (−4.78 to 6.53)
36 → 60	−0.31 (−1.21 to 0.59)	−0.33 (−0.88 to 0.22)
	Child care[h]	Access to library[i]
Screen time → reading, mo		
24 → 36	0.00 (−0.01 to 0.01)	0.01 (−0.003 to 0.02)
36 → 60	0.01 (−0.001 to 0.01)	0.01 (−0.001 to 0.01)
Reading → screen time, mo		
24 → 36	1.13 (−4.58 to 6.84)	0.17 (−5.00 to 5.33)
36 → 60	−0.26 (−0.94 to 0.42)	−0.17 (−0.87 to 0.52)

→, predicting.

[a] Difference in the cross-lagged associations by covariate group.

[b] Defined as low income (CAD$ <60 000; 1) and high income (CAD$ ≥60 000; 0).

[c] Defined as lower education (some high school, graduated high school, and some postsecondary; 1) and higher education (graduated postsecondary, some graduate school, and completed graduate school; 0).

[d] Defined as low maternal reading (below median; 1) and high maternal reading (at or above median; 0).

[e] Defined as low maternal screen use (below median; 1) and high maternal screen use (at or above median; 0).

[f] Defined as at risk (at or above the cutoff score on the BITSEA problem behavior scale; 1) and normative (below the cutoff score on the BITSEA problem behavior scale; 0).

[g] Defined as male (1) and female (0).

[h] Defined as nonparental child care or day care (1) and other (0).

[i] Defined as attending the library (1) and not attending the library (0).

Presumably, families vary on the content and context in which screens are used, and these elements of screen use may have a different association with language and literacy.[36] Third, although this study reveals an association between screen use and reading, further research is needed to determine the specific threshold at which screen use influences reading. Fourth, because of the rapid progression of technology, exposure and accessibility to screens may have changed over the course of this multiwave study.[8] Additionally, although parents are arguably the best informants of child activities between 24 and 60 months, single-informant measurement introduces the potential for bias. With regards to reading, a single item was used to capture the frequency of reading activities at each time point. Although the reading items were designed to reflect the natural progression of reading activities across early childhood, single-item measurement at each time point provides fewer points of discrimination and potentially limits the sensitivity, or variation, in the measure. This study would be strengthened by more detailed measurement of the home reading environment, including parent literacy skills and objective measures of parent-child shared reading experiences (eg, conversational turns, parent engagement, etc).

CONCLUSIONS

With the increased exposure to digital media, screen use is now a regular part of children's day-to-day lives. In response to this increase in exposure, there is a critical need to understand how screen use may be influencing the home learning environment, specifically engagement in off-line enrichment activities such as reading. This study provides support for a reciprocal relationship between screen use and reading activities. Higher screen use at 24 months of age related to lower reading activities at 36 months of age, and in turn, lower levels of reading at 36 months of age related to higher levels of screen use at the next time point. The findings from this study support the need for practitioners, child care professionals, and educators to encourage families to engage in healthy use of screen devices (ie, limited duration) and to encourage device-free time to establish early reading habits.

ACKNOWLEDGMENTS

ABBREVIATIONS

BITSEA: Brief Infant-Toddler Social and Emotional Assessment
CAD: Canadian dollar
CI: confidence interval
RI-CLPM: random intercept cross-lagged panel model

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