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Family Literacy Activities Mediate the Effects of Recreational Screen Time on Children's Language Development

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Abstract

Children's recreational screen time is a public health issue because it has negative effects on various aspects of their development; oral language skills are particularly affected. Given that family literacy contributes positively to the development of language skills, this study sought to answer the following question: Can family literacy activities mediate the negative effects of screen time on the language skills of preschool and school-aged children? Data from 149 children (55% girls) assessed at the ages of 4 and 7 years old confirmed the mediating role of family literacy activities at preschool age. Our results suggest that promoting these activities for preschool children is a relevant strategy to try to reduce the negative impacts of screen time. Hopefully, parents, professionals and health care authorities will consider this suggestion carefully.

Keywords: Recreational screen time; Family literacy activities; Oral language; Mediation.

Abbreviations: Recreational Screen Time (RST), Family Literacy Activities (FLAs)

Importance of Family Environment for Language Development

Language is key to a child's overall development [1]. Delays or difficulties may put the child at risk for various persistent problems, especially in terms of literacy and academic success [1-3]. For example, the longitudinal study by Pagani et al. in 2010 [3], concluded that good language skills at preschool age can predict academic success in the first and third grades. Optimal formation of language skills is therefore a crucial issue for a child's subsequent development, and parents are at the forefront of this process [4,5]. Determining what parents can do to offer a rewarding family environment is one of the most important questions for both health and education professionals. In line with that objective, many researchers have identified the home literacy environment as a key factor promoting language development (see the meta-analyses by Bus et al., [6], Mol et al., [7] National Center for Family Literacy [8]) and pinpoint recreational screen time (RST) as an activity that is unfavorable to language development in preschool and school-aged children (see the summaries and reviews [9-13]).

We chose to study RST and home literacy environment for two reasons. First, both factors are considered public health issues and are therefore the subject of recommendations by relevant organizations [14-22]. Second, several studies show an inverse relationship between these two factors: an increase in one is associated with a decrease in the other [23-26]. Our overall objective in this study is to explore the links between RST, home literacy environment and oral language skills in preschool and school-aged children between the ages of 4 and 7 years. More specifically, we will investigate whether the effects of RST on oral language skills can be explained or mediated by home literacy environment. To ensure that this question is a relevant one, we will further explain the problem in the following three subsections, which document the links between (1) RST and oral language skills, (2) family literacy environment and oral language skills, and (3) RST and family literacy environment.

Recreational screen time and oral language skills

RST involves sedentary activities, whose consequences for children's physical development are already known (e.g., obesity, sleep problems) [27-29]. However, their effects extend beyond this development domain to cognition, and particularly to language. While laboratory studies indicate that the effects of specific

educational content such as Sesame Street or Dora the Explorer can be positive [30,31], several cross-sectional or longitudinal correlational studies document the negative association between typical RST at home and the oral language skills of preschool and school-aged children [10,12,13,32]. Moreover, other researchers have used quasi-experimental and case control studies and concluded that excessive RST leads to oral language problems [33-35].

Most of the studies published on RST at home and oral language focused on structural skills such as word and sentence comprehension and production. However, very little information is available on the effects of RST on pragmatics, a key component of language because it is crucial for effective communication. Starting at age 4 or 5, children acquire the capacity to express their intentions and decode those of others [36]. This sensitivity to the communicative context requires children first to internalize the implicit rules of conversation and then to respect them during conversations [36]. To paraphrase Delahaie [37], pragmatics can be defined in concrete terms as knowing how to use language to socialize with others.

Despite the lack of research on the topic, some clinical evidence suggests that RST affects the pragmatic component of language. On the one hand, pediatricians and other early childhood professionals have observed that children exposed to excessive RST tend to avoid eye contact with their interlocutor and show little interest in initiating or maintaining communication [13]. On the other hand, the preliminary results of a study from our laboratory indicate that preschool and school-aged children with high RST (more than 1 and 2 hours per day, respectively) have more pragmatic difficulties than other children [38]. Several public authorities have adopted recommendations concerning RST for preschool and school-aged children. Some of them encourage parents to limit RST [15,16,18,19], while others emphasize the importance of regulating RST for school-aged children [15,19]. However, despite these efforts, children's RST has continued to grow over the years and has increased drastically as a result of the COVID-19 pandemic [39]. In fact, getting parents to impose a limit on RST appears to represent a sizeable challenge for various reasons. Parents often use screens as a babysitter and may see screens as an educational or an affordable entertainment resource [40-42].

From this perspective, it makes sense to promote healthy lifestyles, not only by focusing on RST per se, but also by mitigating the effects of RST, as suggested by the Institut national de santé publique du Québec [11]. With the goal of contributing to the optimal development of children's oral language skills through aspects of the family literacy environment, this type of strategy could focus on increasing family literacy activities.

Family literacy environment and oral language skills

Although the concept of early literacy may include storytelling [22], the family literacy environment is frequently defined as the family activities or practices, beliefs and resources that support reading and writing abilities [43,44]. Shared reading is central to family literacy activities (FLAs) and has been extensively studied to determine its positive impacts on literacy skills [45,46] and oral language skills [47-50]. In fact, the frequency with which parents engage in shared reading explains up to 8% of the differences observed in language skills and may contribute to significantly reducing the gap between children from different socioeconomic levels (see the meta-analyses by Bus et al., [6] and Scarborough & Dobrich [51]). Shared reading seems to stimulate oral language skills even more than writing skills in children learning to read: "Although joint book reading involves experiences with literacy, the primary impact of the activity may be on oral language rather than literacy at least among pre and beginning readers" ([47] p. 467).

The positive effects of shared reading on oral language development rely on multiple factors. First, children's books contain richer words and more complex syntax than those used during casual conversations held with children [52,53]. Moreover, the level of language used by the parent during shared reading is enhanced compared to the family interactions that take place in daily life [53]. Second, shared reading is a book-centered social activity that creates a context favoring contingent interactions and conversations [54,55]. Although FLAs have been assessed most often through shared reading, these activities can incorporate several other concrete actions related to reading and writing that involve materials other than books (e.g., magnets, recipes or games). Sénéchal and LeFevre's [56] model can be used to grasp the scope of those FLAs classifying them into two major categories. As they do during shared reading, parents can focus a literacy activity with a child on the meaning of the content without teaching the child how to read or write (e.g., learning a nursery rhyme). These are informal literacy activities. However, parents can also engage in formal literacy activities, that is, focus on explicitly teaching letters and sounds (e.g., pointing out that a word is written with two r's or asking the child to find the letter b in a text).

Recreational screen time and family literacy environment

To account for the general decline in reading as a pastime since television, and then electronic devices, arrived on the scene (see the meta-analyses by National Endowment for the Arts [57]), several authors have suggested that there is a negative conceptual link between these two leisure activities. Three inhibitor mechanisms would therefore be possible [26,58,59]. RST might (1) replace the time previously spent reading (displacement hypothesis), (2) reduce interest in reading (depreciation hypothesis), or (3) reduce the capacity or motivation to focus in order to read (deterioration hypothesis). The debate surrounding the accuracy of these explanations has lasted for decades [58,59]. However, the fact that the time children spend watching television is negatively associated with reading has become clearer [26]. Whereas the dominant scientific opinion in the 1960s and 1970s

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agreed that television did not affect the time spent reading in any way, this view changed with the first quasi-experimental and experimental studies on the subject [26]. In their review of the literature published in 1996, Koolstra and Van der Voort observed that "the weight of the evidence seems to favor the assumption that television viewing reduces children's book reading…" ([26] p. 9).

It remains to be seen if Koolstra and Van der Voort's statement still applies to the current generation of children, who grew up in an environment where screens are part of their daily lives and of their relationship with the written word, especially through multimodal literacy [60]. For these digital natives, who live in a culture that is very different from what came before, is it possible that ST and the family literacy environment are no longer interrelated? Could they even influence each other in the same direction? To the best of our knowledge, except for the study by Vandewater et al. [61], all studies published since 2005 that investigated the association between RST at home and family literacy environment have concluded that there is a negative association between these two variables [23-25]. The study by Duursma et al. [23], conducted with 1,464 participants aged between 7 and 12 years, shows that the more books there are in the home, the less time is spent watching television, movies and videos. Froiland and Davison [24] and Khan et al. [25], who also conducted their studies with large samples (more than 500 participants aged around 4 years old), focused specifically on FLAs. Their results are similar and suggest that the more FLAs such as shared reading parents offer, the less television their children watch. It is interesting to note that the analyses by Khan et al. [25] did not detect any contextual feature related to maternal education, household size, and composition, or time spent in nonparental care that could significantly change the inverse relationship observed between RST and shared reading. Still, it is surprising that none of the above-mentioned studies included video games in their measurements of RST, given that this hobby is very popular among children [62,63]. That being said, it seems important for us to investigate RST and FLAs with special consideration for the variable of sex since several studies have shown that boys have higher RST than girls [23,62,63] and spend less time on FLAs [64,65].

Objective and hypotheses

To our knowledge, this study is the first to examine the links between RST, FLAs and language skills simultaneously among preschool and school-aged children. We decided to focus on the ages of 4 and 7 years old to conduct our measurements, with the aim of understanding the children's development before they start school and in second grade, once they have formally started learning to read and write. Due to the longitudinal design of this study, with two measurement times (4 and 7 years), we were able to measure the effects of RST and FLAs on children's language skills over the short and long term. First, we describe RST and participation in FLAs among boys and girls, in order to verify whether these activities are affected by sex. Second, we consider the impacts of RST and FLAs on language skills. Is it true, as the literature suggests, that RST is negatively and FLAs positively associated with language skills?

Finally, and most importantly, we examine the potential mediating role of FLAs. Here it is important to note that, even though a mediation analysis is not a formal test of causality, it reflects a causal sequence in which X affects Y indirectly through mediator variable M [66]. Consequently, we can ask the following question: Can the effects of RST on oral language skills be explained by FLAs? The findings presented in the various sections of the literature review can be used to establish the following general research hypothesis:

FLAs mitigate the effects of RST on oral language skills.

Two underlying phenomena could explain this proposal:

i. The higher RST is, the less frequent FLAs (formal and informal) are.

ii. The less frequent FLAs (formal and informal) are, the poorer the child's oral language skills will be.

Materials and methods

Participants

The data came from a sample from a longitudinal study of 4-, 5- and 7-year-old children and their living environments, which initially included 240 children recruited between 2009 and 2010. Following authorization by the Commission d'Accès à l'information (Quebec access to information commission), the Régie de l'assurance maladie du Québec (Quebec health insurance board) gave the researchers a list of 4,575 children who would have their fourth birthday during the recruiting period. Telephone contact was then established with the 3,000 families for which we were able to find a phone number. Of this group, 1,425 children met the selection criteria, namely: (1) having had normal health at birth (i.e., Apgar > 7, weight > 2,500 g and gestation period of more than 37 weeks); (2) having undergone overall typical development to that date; and (3) having French as one of the languages spoken at home. In the end, the parents of 155 children agreed to participate, but complete data were obtained for just 149. Almost all the children had French as their first language (97.3%). Table 1 describes other characteristics of the families and children in the sample.

Procedure

The parents signed a consent form after reading an information document stipulating that the data would be kept confidential and anonymous and that they had the right to withdraw from the study at any time. A team of two research assistants then went to the child's home for a meeting lasting approximately 90 minutes. While one of the team members administered the cognitive assessment to the child, the other completed several questionnaires with the mother.

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Table 1: Demographic characteristics of the sample (N=149)

Sex	Family income	Mother working outside the household		Mother Education		Family structure	Number of Children
Boys 47 %	Less than 15 000$ 9.4 % 15 000$ to 19 000$ 2.7 % 20 000$ to 24 999$ 2.0 % 25 000$ to 29 999$ 2.7 % 30 000$ to 34 999$ 2.0 % 35 000$ to 39 000$ 10.1 % 40 000$ to 44 999$ 6 % 45 000$ to 49 000$ 4 % 50 000$ to 54 999$ 5.4 % 55 000$ to 59 000$ 2 % 60 000$ to 64 999$ 4.7 % 65 000$ to 69 999$ 2 % 70 000$ to 74 999$ 5.4 % 75 000$ to 79 999$ 3.4 % 80 000$ to 84 999$ 3.4 % 85 000$ to 89 999$ 0.7 % Over 90 000$ 32.9 %	No	26.2 %	High school started	5.4 %	Intact 85.9 % Not intact 14.1 %	1 18.1 % 2 57 % 3 18.8 % 4 6.0 % or more
Girls 53 %		Part time	18.8 %	High school diploma or equivalent	12.1%		
		Full time	55 %	18.8 %			
		College diploma or equivalent University diploma		63.8 %			

Measures

Independent and mediating variables

i. **Recreational Screen time:** The mother reported total RST when the child was aged 4 and 7 years old. This comprised the weekly time spent watching television (series or movies) and playing video games on different platforms (console, computer or mobile device).

ii. **Family literacy activities:** When the child was 4 years old, the parent indicated how often she or he recited rhymes and read to the child. A third question assessed how often the child used pencils to write or pretend to write at home. The frequency of these activities was evaluated using a 7-point Likert scale (0 = never; 1 = less than once a month; 2 = 1 to 3 times a month; 3 = once a week; 4 = 2 to 3 times a week; 5 = 4 to 5 times a week; 6 = 1 once a day; 7 = several times a day).

When the child was 7, the parent responded to a series of items from Martini and Sénéchal's [67] questionnaire. The items were designed to determine the frequency of formal and informal literacy activities that the parent did or had done with the child and the various tools the parent used to help the child learn the letters of the alphabet and how to write or read words. The response scales always measured frequency on a 5-point scale (1 = never; 2 = rarely; 3 = sometimes; 4 = often; 5 = very often). The interitem reliability was excellent (Cronbach's alpha .91, 95% confidence interval [CI] .88 to .93) as evaluated by Martini and Sénéchal' [67]. To enhance the comparability of responses at the two measurement times, we decided to recode the 4-year-old children's data so they could be presented on a 5-point Likert scale (1 = never; 2 = rarely [less than 3 times a month]; 3 = sometimes [once a week]; 4 = often [2 to 5 times a week]; 5 = very often [at least once a day]).

Control variables

i. **Performance intelligence quotient:** The Wechsler Preschool and Primary Scale of Intelligence, third edition (WPPSI-III; Wechsler, 2002) assesses the cognitive and linguistic development of children aged 2 years 7 months to 7 years 3 months. The performance intelligence scale measures the child's abstract and conceptual reasoning capacity. It comprises three mandatory subtests: Block Design, Matrix Reasoning and Picture Concepts. The Block Design subtest assesses the child's ability to analyze and synthesize abstract visual stimuli and form nonverbal concepts. The Matrix Reasoning subtest evaluates the child's visual information processing and abstract reasoning skills. The Picture Concepts subtest measures the child's abstract and categorical reasoning ability. The short version of the WPPSI-III

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was administered to the 4-year-old children, and the performance intelligence quotient (PIQ) was used [68]. PIQ comprises the scores obtained on the Block Design, Matrix Reasoning, and Picture Concepts subtests. The internal consistency and test-retest reliability coefficients showed good psychometric qualities (α = 0.94; *r* = 0.81).

ii. **Socioeconomic status** Socioeconomic status was estimated based on family income as reported by the mother during the research assistants' home visits.

Dependent variables

i. **Verbal comprehension:** Verbal IQ (VIQ) and verbal comprehension index (VCI) come respectively from the WPPSI-III and the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV; Wechsler, 2005), two widely used, norm-referenced (*M* = 100, *SD* = 15) Wechsler intelligence scales that have been validated for a French-Canadian population [67,68]. For the 4-year-olds, we calculated VIQ based on the following three subtests from the short form of the WPPSI-III: Information, Vocabulary, and Word Reasoning [68]. The Information subtest measures general knowledge by asking the child various questions (e.g., What is an umbrella?). In the Vocabulary subtest, the child must define words read aloud by the examiner; the aim is to assess the child's understanding of information and the scope of his/her vocabulary and concepts. The Word Reasoning subtest is constructed similarly to riddles with the aim of highlighting the child's deduction, abstraction and synthesis skills; based on a series of increasingly specific verbal clues, the child must identify the object being described. The internal consistency and test-retest coefficients are good (α = 0.95; *r* = 0.87).

For the 7-year-old children, VCI represented a composite score obtained based on the results of three WISC-IV subtests [69]. The Similarities subtest, in which the child must explain why two words are similar (e.g., an apple and a banana are both fruit), mainly measures verbal reasoning and development of concepts. For the Vocabulary subtest, the child must define words shown in pictures or read by the examiner (e.g., What is a dog?). The Comprehension subtest contains questions about daily life, which probe the child's understanding of general principles and social situations (e.g., Why do people go to school?). Wechsler [69] reports excellent internal consistency coefficients (α = 0.80 to 0.90) and very good test-retest reliability (*r* = 0.80 to 0.90) for the WISC-IV.

ii. **Pragmatic skills:** We measured pragmatic skills by so-called indirect methods, which relied on the mothers' reports. For the 4-year-old children, we used a test for preschool children's social-conversational skills [70,71]. The 20 items in the instrument cover two kinds of skills children might apply in conversations, namely awareness of the interlocutor (e.g., the child answers questions that are asked) and the ability to assert themselves (e.g., the child asks questions). Responses are made on a 5-point Likert-type scale (1 = never, 2 = almost never, 3 = sometimes, 4 = often, 5 = always).

We assessed the 7-year-old children's pragmatic skills with the French version of Bishop's [72] Children's Communication Checklist, which is considered to examine this aspect of language. The questionnaire, which contains 70 items divided into 10 subscales, measures children's problems in various communicative domains. The first four subscales refer to skills related to the form and content of language (A = Speech; B = Syntax; C = Semantics; D = Coherence). The next four refer to pragmatics per se (E = Inappropriate initiation, F = Stereotyped language; G = Use of context; H = Nonverbal communication). Finally, the last two subscales refer to certain characteristics that may indicate autism spectrum disorder (I = Social relations; J = Interests). The total score has an excellent internal consistency coefficient for the sample studied (α = 0.80).

Results

We first conducted descriptive and inferential analyses using repeated-measures analyses of variance (ANOVAs) to describe RST and FLAs in boys and girls aged 4 and 7 years old (Objective 1). We used the Greenhouse–Geisser procedure to control for Type 1 errors. Next, we investigated cross-sectional and longitudinal correlations to examine the associations that RST and FLAs, respectively, have with language skills (comprehension and pragmatics), and more specifically to verify the prerequisites for mediation analyses. In fact, to find out whether FLAs explain the impacts of RST on language skills through indirect effects, one must first ensure that the independent variable is significantly correlated with the mediating variable and the mediating variable is significantly correlated with the dependent variable [66]. In other words, we did mediation analyses at age 4, age 7 and longitudinally only when the following conditions applied: (1) the higher RST is, the lower FLAs are; and (2) the less frequent FLAs are, the poorer the child's oral language skills are.

Finally, when the prerequisites were respected, we conducted mediation analyses in accordance with model 4 of the Process module in SPSS [66]. To determine whether the effect of RST observed on oral language skills is mediated by participation in FLAs, we assessed indirect effects with the bootstrap test. Our calculation and interpretation of effect sizes were based on the work of Cohen [73,74], and the significance level was set at 0.05. All correlation and mediation analyse we did control for socioeconomic status, PIQ at age 4 and the child's sex.

Objective 1: RST and Participation in FLAs among Boys and Girls

Table 2 shows similar RST for boys and girls at age 4, whereas at age 7, boys experience higher RST than girls ($F(1, 147) = 4.98$, $p \leq .05$, $\eta^2 = .033$). The frequency of participation in FLAs is higher for girls than boys at age 4 ($F(1, 147) = 7.54$, $p \leq .05$,

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η^2 = .050), whereas it is statistically equivalent for both sexes at age 7. However, the variable "sex" explains a negligible portion of the variance each time. To examine the changes in RST and FLAs over time (longitudinal effect), we carried out repeated-measures ANOVAs on age with girls and boys separately. The results showed that both sexes spent more time in front of screens at age 7 than at age 4 and this age effect is greater in boys (girls: $F(1, 78) = 6.643$, $p \leq .01$, $\eta^2 = .078$; boys: $F(1, 69) = 23.016$, $p \leq .01$, $\eta^2 = .25$). As for the frequency of FLAs, the analyses did not reveal any age difference (girls: $F(1, 78) = .048$, $p = .825$; boys: $F(1, 69) = .109$, $p = .743$).

Table 2: Descriptive Data on Recreational Screen Time and Family Literacy Activities according to Sex and Age.

	4 years old						7 years old					
	Boys (n = 70)		Girls (n = 79)		Total (n = 149)		Boys (n = 70)		Girls (n = 79)		Total (n = 149)	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Recreational screen time (hours/week)	9.44	6.09	8.94	6.17	9.18	6.12	13.21	8.03	10.56	6.45	11.81	7.34
Family literacy activities (frequency/week)	4.02	.77	4.35	.60	5.47	2.26	3.27	.43	3.35	.53	3.32	.49

Objective 2: Association between RST, FLAs and Oral Language Skills

Table 3 shows the cross-sectional and longitudinal correlations among the different variables studied. First, RST is correlated with verbal comprehension at all measurement times and longitudinally. The higher RST is at age 4 and age 7, the lower verbal comprehension skills are at those ages. In addition, the greater the exposure to RST at 4 years old, the weaker verbal comprehension is at age 7. Regarding the pragmatic component of language, we found a cross-sectional association with RST at age 7, as well as a longitudinal association. The higher RST is at age 7, the more common pragmatic problems are at that age; moreover, the higher RST is at age 4, the more common pragmatic problems are at age 7. We observed no significant correlation between RST and pragmatic skills at 4 years old.

Table 3: Cross-Cutting and Longitudinal Correlations.

	4 years n = 149				7 years n = 149			
	RST	FLAs	Comprehension	Pragmatic skills	RST	FLAs	Comprehension	Pragmatic skills
4 years								
RST	1	-.229**	–.264**	–.115	.574**	–.187*	–.220**	.199**
FLAs	–.229**	1	.270**	.208*	–.229**	.280**	.280**	–.128
Comprehension	–.264**	.270**	1	.326**	–.249**	.072	.672**	–.273**
Pragmatic skills	–.115	.208*	.326**	1	–.223	.162	.331**	–.431**
7 years								
RST					1	–.158	–.242**	.172*
FLAs					–.158	1	.134	–.163*
Comprehension					–.242**	.134	1	–.228**
Pragmatic problems					.172*	–.163*	–.228**	1

Notes: At age 7, pragmatics is represented by a score for problems. Performance IQ at age 4, sex and family socioeconomic status were controlled for. ST: number of hours of screen time per week. FLAs: frequency of family literacy activities per week. * Correlation significant at $p = .05$. ** Correlation significant at $p = .001$. RST: Recreational screen time. FLAs : family literacy activities.

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Then, for all ages, we examined the significance of correlations between RST and FLAs and between FLAs and language skills (prerequisite for testing mediation effects). At age 4, the more RST children experience, the less they take part in FLAs, and in turn, the less they participate in FLAs, the lower their verbal comprehension and pragmatic scores are. Over the long term, similar correlations are seen for verbal comprehension. The more RST children are exposed to at age 4, the less they participate in FLAs at that age, and the weaker their verbal comprehension is. We tested three mediation models, shown below in the form of questions.

Can participation in FLAs at age 4 explain the negative effects of RST…

i. On verbal comprehension at age 4?

ii. On pragmatic skills at age 4?

iii. On verbal comprehension at age 7?

Objective 3: Testing the Mediating Role of FLAs

Figure 1 illustrates the three mediation models we tested. All indirect effects were significant. FLAs at 4 years of age mediated the effects of RST on pragmatic skills at that age (A and B). In addition, FLAs at age 4 mediated the long-term effect of RST on verbal comprehension (C). We describe these effects in more detail in the following paragraphs. Parts A and C of Figure 1 show partial, or complementary, mediation [75] since the direct effect of RST on verbal comprehension remains significant despite the consideration of FLAs. Although, in statistics, the gold standard would be for the indirect effect to completely counteract the direct effect, this rarely happens; in general, mediation accompanies the direct effect [76]. According to Zhao et al. [75], this kind of mediation confirms the accuracy of a model, but it also means that other mediators could enhance that model.

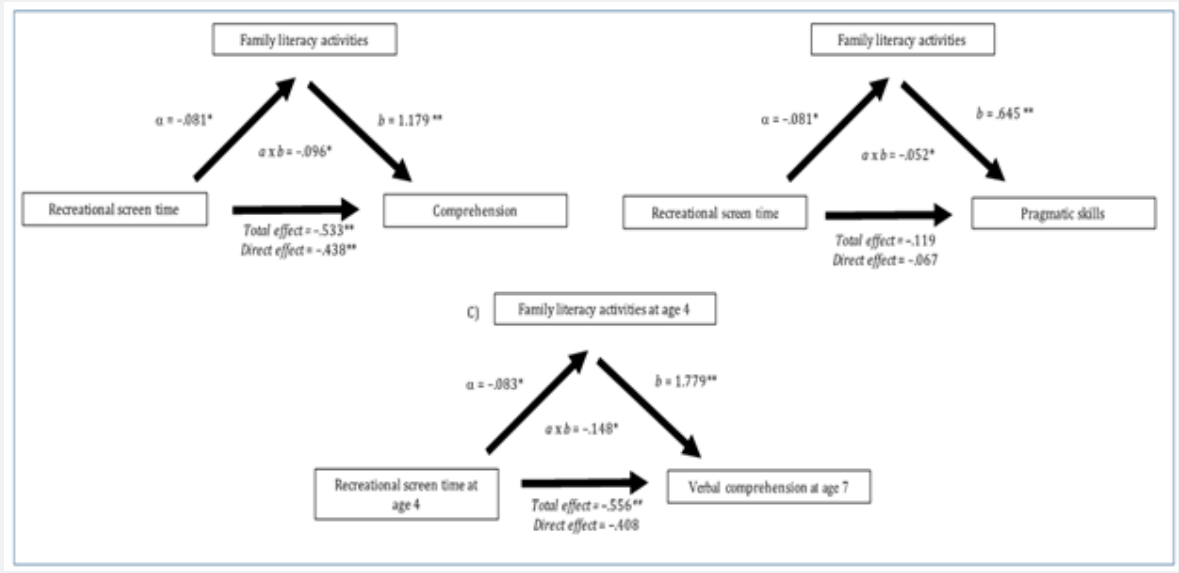

Figure 1: Significant meditation of family literature activities.

Notes: Performance IQ at age 4, sex and family socioeconomic status were controlled for a, b and c are the unstandardized coefficients of a linear regression.

*Effect significant at p= .05

**Effect significant p= 0.001.

Part B shows overall that RST is significantly associated *only* through the mediator variable of FLAs since the total effect is not significant. This situation, which is less common than partial mediation, still confirms the mediation model [75] given that, as Preacher and Hayes [77] point out, the only criterion for demonstrating a mediation effect is the significance of the indirect effect. In light of these results, we can therefore say that FLAs at age 4 explain the short-term effects of RST on verbal comprehension and pragmatic skills and the long-term effects of RST on verbal comprehension.

Discussion

Our study was the first to explore the correlations between RST and FLAs in their effects on language development in 4- and 7-year-old children. We documented some important issues for parents and professionals in the health and education fields. We selected the targeted language skills – verbal comprehension and pragmatic skills – because they cover a broad spectrum of language development: the former is the foundation for grasping the literal meanings of words and sentences, while the latter are essential for contextualizing that meaning in social communication.

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Objective 1: RST and Participation in FLAs among Boys and Girls

The cross-sectional analyses related to Objective 1 show for the first time that girls take part in FLAs more often than boys at age 4. This result echoes the finding that girls read more often than boys [23,62,63] and confirms the importance of sex as a variable when the topic of study is shared reading and FLAs more generally. There are two possible explanations of this difference. First, it is possible that parents initiate fewer FLAs with boys than with girls because boys show less interest than girls in activities related to books [78]. On the other hand, it is also possible that parents initiate fewer FLAs with boys than with girls because they have a gendered view of literacy [79]. Considering sex as a variable is also particularly important in the investigation of RST, given that several studies have shown that boys have higher RST than girls [23,62,63]. Our study is no exception; we found a sex-based difference in RST at age 7. Previous findings suggest that boys have higher RST because they play more electronic games at school age [81,82]. However, despite the difference in boys' and girls' gaming time, the similarity of total RST for boys and girls that we found for preschoolers bolsters the idea that, at this age, television is still the medium that both sexes use most commonly, despite the proliferation of technologies [63].

Between the ages of 4 and 7 years, the observed increase in RST is in accordance with previous publications on the topic [63,82]. Among other things, this change illustrates the finding that parental mediation becomes more flexible when children start school and their sphere of influence expands to include friends [83,84]. The fact that this increase is more marked in boys may, as mentioned above, be explained by their greater interest in electronic games at school age and the fact that these games become a recreational activity played with friends [63]. At first sight, the decrease in FLAs we observed between 4 and 7 years of age is more difficult to explain, since it corresponds to the age when the school environment places a lot of emphasis on literacy, and it affects girls strongly (the effect size is 0.60). We believe that autonomous literacy activities replace FLAs as a child becomes able to read.

Objectives 2 and 3: Association between RST, Oral Language Skills and FLAs, Testing FLAs' Mediating Role

The results of our study indicate that RST is negatively associated with both language skills and FLAs for children in the digital generation. Thus, they support the findings of other recent studies [23-25] and suggest that the damaging effects of RST persist over time despite the in-depth transformation of society that has taken place due to the proliferation and omnipresence of screens. We present the most important results below. The cross-sectional and longitudinal correlations between RST and verbal comprehension remained significant even when we controlled for the child's PIQ and family income. In the long term, we observed a harmful effect of RST on a language component rooted in social interactions, namely pragmatics. The higher the RR children are exposed to, the more likely they are to have pragmatic problems at age 7. Since pragmatic skills are crucial for social adaptation [36,37], our result supports several studies showing that RST has a negative impact on children's socialization [3,85,86]. According to Pagani and her colleagues [87], long hours spent in front of a screen deprive a child of many family interactions, which are necessary for the acquisition of basic social skills. The same explanation may apply to the connection between RST and the pragmatic component of language. On the other hand, it will be essential for other researchers to replicate these results, which should also provide additional data to confirm why the negative effect of RST on pragmatics is not observable at age 4 but is at age 7. One could plausibly argue that pragmatic deficits become observable over time, as children accumulate additional RST during their development and exceed a critical threshold. For example, in its document on digital health, the Canadian Paediatric Society expressed the idea that the effects of RST on cognitive development may be cumulative [16].

However, there are also two alternative hypotheses related to our measurement tools. First, it is possible that a correlation between RST and pragmatic skills already exists at age 4, but that our measures, as reported by the mothers, were not adequate to detect it because pragmatic skills are not fully developed at preschool age [36], and consequently the effect may be more difficult for mothers to observe. Second, pragmatics covers a wide range of skills [88], and the instruments we used at ages 4 and 7 differ conceptually. At age 4, the mothers had to report the children's various behaviors related specifically to conversational skills (initiative, self-assertion and sensitivity to the interlocutor), whereas at age 7, the questions focused more on high-level pragmatic skills that enable one to understand the implicit aspects of discourse (e.g., considering the other person's emotions or intentions and understanding metaphors). Consequently, it is possible that RST affects pragmatic abilities in different ways and has a greater impact on so-called high-level pragmatic skills.

Except for the correlation between RST and pragmatic skills at age 4, all the correlations between RST and language skills were significant. Overall, our results confirm the negative effects of RST on children's oral language development over the short and long term demonstrated by previous studies [10,13,26,58]. Thus, limited RST for preschool and school-aged children may favor optimal language development. Our laboratory encourages limiting RST to 1 hour a day for preschool children as recommended by the WHO [19], Canadian Paediatric Society [16] and American Academy of Pediatrics [14]. For school-aged children, we suggest following the Canadian Society for Exercise Physiology [18] guidelines, which recommend a maximum of 2 hours of RST per day. The choice of this threshold is based on a study conducted in our laboratory that showed that children who respect the above-mentioned limit have better comprehension skills [81] and on the study by Walsh et al. [89], which used a database of over

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4,000 children aged 9 and 10 years old. Supporting our results, that largescale study indicated that a maximum RST of two a day is associated with better overall cognitive functioning. However, limiting RST provides maximum benefits only if it is part of a family plan that promotes other healthy life habits such as getting enough sleep [89]. Our results also suggest that such a family plan should include participation in FLAs at preschool age since this may contribute to mitigating the long-lasting effects of RST on children's language skills.

This was the first time, to our knowledge, that FLAs were tested as a variable that could mediate the relationship between RST and language skills. Three patterns of results emerged. FLAs at age 4 explain the short-term effects of RST on verbal comprehension and pragmatic skills and the long-term effects of RST on verbal comprehension. Note that the negative correlation between RST at 4 years and verbal comprehension at 7 years disappears completely when we take FLAs at age 4 into consideration. The causal mechanism underlying these three significant mediation results is as follows: the higher RST is, the less frequent FLAs are, and the less frequent FLAs are, the poorer the child's oral language skills are.

Although our research design was correlational and not experimental, interpretation in terms of causality is legitimate for two reasons. First, we controlled for the child's IQ and the family's socioeconomic status, two key variables [58]. In addition, the application conditions for mediation tests necessarily involve a sequence of effects with known directions (X affects M, which in turn affects Y; [66]). The results of the mediation document FLAs' ability to explain the associations between RST and language skills. Our results mainly suggest that participation in FLAs at preschool age can mitigate the negative effects of RST on children's language development, particularly by reducing RST. In other words, the goal of reducing children's RST could be met by encouraging FLAs. This strategy, which involves targeting the mediating behavior to change the target behavior, is particularly interesting during the current pandemic, where it can be difficult to reduce RST. Moreover, a mediation-based intervention model has been proposed by the Quebec public health institute to reduce RST [11] and has been found to have worthwhile results in the field of physical health [90].

At the same time, the results related to mediation confirm the connection between RST and the family literacy environment already examined by several previous studies [23-25]. More specifically, they support the correlation found by Khan et al. [25] indicating that the more a parent reads to a child, the less television that child watches. These authors also help us to quantify the desired frequency of FLAs since their results show that the television time of children who engage in at least one shared reading session per day with a parent is less than 2 hours a day. Moreover, introducing a shared reading routine is important because it exposes the child to richer language and creates a dynamic conversation with contingent interactions [53-55] that is not encountered when watching television [55].

Limitations

Despite the advantages of using an existing database, it requires one to adjust *a posteriori* to the choice of measurement instruments chosen earlier [91]. The two main limitations of our study are based on this issue, which is inherent in secondary data analysis. First, it is important to emphasize that family literacy activities were evaluated in different ways at age 4 and age 7. At the first measurement time, the frequency of FLAs was assessed with a limited number of items in a homemade questionnaire, whereas it was assessed in more detail using Martini and Sénéchal's [67] questionnaire at the second measurement time. Nevertheless, it is probable that the evaluation at age 4 did not suffer from a lack of sensitivity, given that the items concerning key FLAs such as reading a book or reciting a nursery rhyme to the child.

In addition, several measurements were reported and this data collection method – paper-and-pencil or online – may have generated a social desirability bias [92]. Consequently, it is very probable that the children's RST (undesirable behavior) was underestimated whereas the frequency of FLAs shared with the children (desirable behavior) was overestimated. It is interesting to note that, despite a potential underestimation of RST, the results were significant. Thus, the negative associations found between RST and oral language skills cannot be doubted. They testify to a phenomenon that might otherwise have been even more obvious.

That being said, the questionnaire used to assess RST presents certain deficiencies that we will address in our future studies. First, none of the questions specifically refers to the weekend, a period when recreational activities involving screens are more frequent and last longer [93]. Thus, it is very probable that RST was again underestimated. This situation will be rectified in future but does not cast any doubt on the results we obtained here. On the contrary, a more accurate assessment of reality might strengthen the RST effects we observed. Second, the questionnaire does not allow us to evaluate the context in which the screen activities took place. Were the children alone or with one or both parents? This question is an important one because "co-viewing" seems to mitigate the developmental risks related to RST [32]. Nevertheless, we know that children's RST represents an opportunity for parents to get their housework done [40,41] so we believe that co-viewing is not sufficiently frequent to change the conclusions of this study.

A final limitation concerns the fact that we did not take screen content into consideration, that is, whether or not the shows watched, or games played were educational. This information was collected but we did not consider it in this study, in which we wanted to emphasize FLAs. Including content would have reflected the American Academy of Pediatrics' new position, which clearly highlights the quality of screen content. At the Academy's Growing

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Up Digital: Media Research Symposium, "Panelists reiterated that media content matters more than the media platform or time spent with media" ([94], p. 3), [93

Conclusion

Despite these limitations, we believe that the results are relevant for parents, health professionals and public health authorities. As a whole they corroborate the harmful effects of RST on children and highlight the importance of taking part regularly in FLAs at preschool age to foster children's language development, reduce RST and mitigate the negative effects of RST on language development.

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Conflicting Interests

The authors declare that there are no conflicts of interest concerning the authorship and publication of this article.

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