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SYNOPSIS

Objective. Early screen exposure is associated with poorer attention, inhibitory control, and language development outcomes. However, the content and context of media exposure are better predictors of outcomes than overall amount. The present study evaluated whether infants' digital media exposure and maternal digital media use were concurrently and longitudinally associated with infant development in 187 infants at 4 and 8 months. ***Design.*** Mothers completed a questionnaire on family media exposure in different contexts, the short form of the MacArthur-Bates Communicative Development Inventories, and the Developmental Profile 3. A series of multiple linear regressions was performed to investigate associations between media use and infant development in the socioemotional, communicative and cognitive domains. ***Results.*** Positive maternal strategies such as using media for educating and amusing the infant were positively associated with socioemotional development at 4 months of age; time dedicated to reading books with the infant (either electronic or paper books) and using screens to communicate were positively associated with infant communicative and socioemotional development at 8 months of age. Mothers' overall usage of media and use of digital media during childhood routines, as well as the time infants spent daily on a device at 4 and 8 months of age, were associated with lower emerging socioemotional and communicative skills. ***Conclusions.*** Findings highlight the potentially positive and negative impacts of very early digital media exposure and could have public health significance.

INTRODUCTION

New digital technologies (smartphones, tablets, video games, computers, audio books, etc.) are part of daily life and consequently may have a significant impact on children's development and on parent-child relationships from the first months of the infant's life. Pediatricians initially recommended no screen

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exposure for children under 2 years of age (Bozzola et al., 2018), a limit however subsequently lowered to 12 months by the World Health Organization (2019). Early exposure to screens may have negative effects on children's health and development as it may interfere with important aspects of children's lives, such as outdoor play, social interactions (with peers and adults), and sleeping patterns (Cheung et al., 2017; Courage & Howe, 2010; WHO, 2019). Historically, concerns about media technology focused on a specific device and on the contents children were exposed to, but with the rapid expansion of mobile digital media technology new questions and concerns have arisen, including a new definition of increasingly dynamic and interactive contexts in which children use media (Lauricella et al., 2017). Both the duration of screen exposure and the quality of context and content predict developmental outcomes (Barr & Linebarger, 2017). The Dynamic Relational Ecological Approach to Media Effects Research (DREAMER) framework (Barr et al., 2024) considers how patterns of media use in the household affect short- and long-term outcomes. Specifically, the DREAMER framework incorporates elements of family systems and relational theory and considers the context of media use, including joint use and interference caused by media use as well as cumulative effects of media exposure over time on children outcomes. This framework also considers structural factors that impact overall screen use. The present study longitudinally and comprehensively considers family media ecology focusing on very early infancy and assesses the DREAMER framework.

One notable structural factor that changed media use patterns across the globe was that during the COVID-19 pandemic and home lockdowns was about a 15% increase in the use of information and communication technologies compared with the pre-confinement period (Ammar et al., 2020). Families were affected by childcare closures and balancing work and home. Increased media use served several functions, including the need to connect with family and to occupy, entertain, and educate children (Bergmann et al., 2022; Gueron-Sela et al., 2023; Hartshorne et al., 2021; Ribner et al., 2021). When used to connect with family via video chat, such media use potentially diminished the negative effects of the quarantine (Strouse et al., 2021).

Thus, it is timely from a theoretical perspective to use the DREAMER framework to explore the effects of early exposure to electronic devices on children's development. Doing so may help to provide anticipatory guidance to professionals and parents to mitigate potential risks and to better adapt technologies to the healthy development of children growing up in an increasingly digital world. It is, however, challenging to capture early media exposure due to the rapidly changing digital landscape and to potential parental estimation error when using self-reports that may prevent them from accurately estimating the extent to which children are exposed to media during family's daily life (Rusnak & Barr, 2020; Vandewater & Lee, 2009). To reflect the current digital landscape, measures of media exposure need to include more

traditional devices, such as TV and DVDs, as well as newer mobile technology (Barr & Linebarger, 2017).

Media and Cognitive Development

Several aspects of media, including screen time and parents' motivations for media use, could potentially be associated with children's temperament and developmental outcomes in children.

Global Screen Time Estimates. Screen time may displace other activities which are critical for cognitive development. Studies using global screen time estimates have reported negative associations between early exposure to media and infants' attention, linguistic, cognitive, and social development (Christakis et al., 2004; Sundqvist et al., 2023; Zimmerman & Christakis, 2005, 2007). For example, McHarg et al. (2020) found that parental reports of regular exposure to screen-based media, specifically television, tablet, and computer, at 4 months of age predicted poorer performance on an inhibition test at 14 months, in which children were asked not to touch a glittery wand in front of them (the Prohibition Task; Friedman et al., 2011), but was unrelated to either cognitive flexibility or working memory at the same age.

Content of Media Use. The content of media is also associated with developmental outcomes. Specific types of content are negatively associated with children's executive functions during the preschool period, as measured through working memory, inhibitory control, problem solving, and delay of gratification tasks (Helm & McDermott, 2022; McHarg et al., 2020). For example, immediately after viewing fast-paced fantasy-themed television programs, 3- and 4-year-old preschool children scored worse on executive function tests than children exposed to educational programs or engaged in drawing (Huber et al., 2018; Lillard & Peterson, 2011). In a small longitudinal study, Barr et al. (2010) found that exposure to background and entertainment television programs during infancy was associated with parent reports of poorer executive functioning in 4-year-olds. Conversely, child-directed programs were not associated with poorer executive functioning. McDaniel and Radesky (2017) also reported that, when parents were more frequently distracted by their own media (specifically, mobile phone, tablet, video game console, television), 3- to 5-year-olds were reported to have more behavioral problems. Finally, different children might be differentially susceptible to exposure to different media content. For example, Linebarger et al. (2014) found that, for families with fewer resources, educational TV programs were associated with better executive functioning, but made no difference either positively or negatively for 2- to 8-year-olds growing up in highly resourced homes.

Media Device. Findings comparing the effects of interacting with interactive devices versus non-interactive devices are mixed. Some studies showed that playing interactive video games has negative effects on children's learning, but others report improvements in visual-spatial processing, representational skills, executive functions, and working memory (Anderson et al., 2017). Furthermore, in some cases, children aged between 24 and 36 months can learn more easily from touchscreen devices than television, due to the ability of touchscreen technologies to directly and actively involve the children (i.e., moving the icons on the smartphone with a finger; Anderson et al., 2017). In addition, there is a small positive relation between touchscreen use and the general cognitive executive function score in 10-month-old infants (Lui et al., 2021). Therefore, when assessing the potential impact of media exposure on developmental outcomes, it is crucial to consider the characteristics of the electronic device.

Media and Linguistic Development

Learning to communicate is a major developmental milestone, and therefore it is important to examine relations between the use of multimedia devices and language development. Excessive screen time might disrupt ongoing parent-child interactions by potentially decreasing both the quantity and quality of language input. Between 4 and 6 months of age, infants interact dyadically with other people, expressing and sharing affect and attention in a turn-taking sequence, and they also learn to interact dyadically with objects, by grasping, mouthing, and manipulating them (Fogel et al., 1999; Striano & Rochat, 1999). Then, between 7 and 12 months of age, infants begin to engage in interactions that are triadic (i.e., sharing attention with one another in the referential triangle of the child, adult, and objects in the environment; Adamson, 2018; Tomasello & Carpenter, 2007). At this time, infants begin to monitor and to be influenced by caregivers' reactions to jointly attend objects. In the following months, through gaze following, imitative learning, and social referencing, and with increasing experience in co-viewing videos, caregivers' emotional reactions to a video will eventually guide children's own understanding of the video (Demers et al., 2013; Martin et al., 2014; Strouse et al., 2018). As early language is largely acquired through triadic social interactions, it is important to consider infants' attentional skills, parental involvement, and media use during everyday parent-child exchanges.

Infants prefer child-directed speech over adult-directed speech (Bergelson & Aslin, 2017; Dunst et al., 2012), and child-directed speech is one of the best predictors of children's language development (Weisleder & Fernald, 2013). Fernald et al. (2008) used the "Looking-while-listening task" to test infants' ability to fixate the image corresponding to the word heard in a sentence. They

found that more child-directed speech at 19 months, as opposed to overheard speech, is associated with better language processing (as indicated by the ability to fixate the image corresponding to a word heard in a sentence) and with vocabulary size at 24 months (Weisleder & Fernald, 2013).

Perhaps due to rapid and complex communicative development during the first 2 years of life, the amount of television viewing is associated with reduced vocabulary and grammar skills (Sundqvist et al., 2021; Zimmerman et al., 2007) and reduced opportunities to interact, indexed via fewer children's vocalizations and poorer adult vocabulary input (Christakis et al., 2009). Moreover, background television exposure has negative effects on language development, decreasing the number of children's words and utterances spoken per minute and the number of new words per minute spoken by the parent (van den Heuvel et al., 2019). Additionally, Corkin et al. (2021) reported that more audible notifications on parent mobile phones were associated with poorer parent-infant interactional quality and decreased vocabulary scores measured at 20 months. Children's use of mobile devices, such as mobile phones, tablets, and video game consoles, was associated with delays in expressive language at 18 months of age (van den Heuvel et al., 2019).

However, exposure from the age of 6 months to well-designed educational TV content, that refers to children's real-life experiences, routines, and familiar objects, is associated with vocabulary gains at 30 months of age (e.g., Linebarger & Vaala, 2010; Linebarger & Walker, 2005), and between 3 and 5 years of age (Neuman et al., 2019). In addition, supportive contexts, where parents jointly engage with their infants around media (e.g., video viewing and interactive games), could help infants to fully understand and process any newly acquired words (Sundqvist et al., 2021); this is also true when it comes to traditional book reading, which provides opportunities for communication, affinity to shared content, and vocabulary learning (Anderson et al., 2017).

The Influences of Temperament, Context, and Parental Practices on Infants' Media Exposure

Temperament. Parents have different attitudes toward and motivations for using media and practices surrounding media (Nikken, 2019). Parents from Western countries regard video watching as an activity children can do alone, and they often use it to entertain their children while they are busy or to calm them down when upset (Nikken, 2019; Radesky, Kistin, et al., 2014; Troseth et al., 2016). Individual differences in infant temperament are associated with different instrumental media uses. Parents may use media, specifically mobile devices such as phones and tablets, to calm young children, much like "comfort food," especially when they perceive their children to have a more difficult temperament (Gordon-Hacker & Gueron-Sela, 2020; McDaniel & Radesky, 2018). Parent motivations for media use are also associated with language

outcomes. Parents' use of media for connection and education predicts higher expressive language, whereas media use to calm predicts lower expressive language in 17- to 30-months-olds (Kucker et al., 2024).

Temperament and socioemotional development are closely linked. Yet only recently have relations between these domains, how they are associated with early media exposure, and the directionality of these relations been investigated. Wai Wan et al. (2021) examined media exposure and socioemotional function in 6- to 24-month-old infants, demonstrating that screen time was associated with more externalizing problems and poorer socioemotional competence.

Family Context. Family context is also associated with early media use. Maternal and paternal levels of education are inversely related with children's screen exposure (Anand & Krosnick, 2005; Kılıç et al., 2019; Paulus et al., 2024). Some studies show that having an older sibling is associated with more media use (Durham et al., 2021), whereas others report that having siblings is a protective factor which reduces children's media usage (Davies & Gentile, 2012; Paulus et al., 2024).

Parent Media Use. Relatively little research exists on the amount of time parents themselves spend on screens. Beyens and Eggermont (2014), in a survey of 844 children between 6 months and 6 years of age, found that parents' time spent watching television was the best predictor of children's viewing time. The authors suggested that parents who spend most of their time watching television may provide fewer options, like reading books or playing outside, to their children. Because parents are essential in managing how media usage affects their infants, it is vital for future studies to focus on how parents incorporate their own media use into family activities (Beyens & Eggermont, 2014).

Use of Media During Daily Routines. Multimedia devices are often used during daily routines with infants, especially when driving, at mealtimes, and during bedtime routines (Sundqvist et al., 2021). Bellagamba et al. (2021) demonstrated that the duration of screen exposure (TV and tablets) is inversely proportional to the duration and quality of sleep in 8- to 36-month-olds. The number of devices in the household during daily routines may distract children's attention from other activities and is associated with worse regulation of bedtime routines, delaying the time to go to sleep. Indeed, exposure to television both during the day and just before going to bed can produce an excitatory state of the nervous system, which increases children's resistance to going to bed, which is related to a decrease in the number of sleeping hours in children younger than 3 years (Brown & Council on Communications and Media Executive Committee, 2011). Additionally, more parental digital media use (e.g., TV, smartphones, tablets,

computers, DVD players) during daily routines is negatively associated with child language development at 2 years of age (Sundqvist et al., 2021).

The Present Study

Aims. As infancy is a period of rapid communicative and cognitive development, and media are embedded in the overall family ecology (Barr & Linebarger, 2017; Barr et al., 2024; Fox et al., 2010), examination of associations between early media use and infant outcomes is warranted. Thus, we examined concurrent and longitudinal relations between maternal digital media use and infants' digital media exposure and different developmental domains at 4 and 8 months of age, a period when there is a transition from engaging in prolonged face-to-face attention to shifting and coordinating attention from person to objects in mother-infant communication (Lavelli & Fogel, 2002; Tomasello & Carpenter, 2007).

Hypotheses. Based on the literature, we expected that (1) higher levels of infant digital media exposure would be associated with lower socioemotional, cognitive, and communicative development, as digital media activities may displace in-person face-to-face interactions between caregivers and infants in the first months of life. Moreover, we hypothesized that (2) higher levels of maternal reading time and greater time spent by mothers in joint activities with infants through book reading and media engagement would be positively associated with children's communicative development. Based on the results of Sundqvist et al. (2021), we also expected that (3) a higher likelihood of parental digital media use during daily routines would be negatively associated with infant communicative development. Additionally, based on previous research on background screen exposure (Barr et al., 2010; Pempek et al., 2014), we expected that (4) background TV would be negatively associated with infant communicative development. Finally, as our data were collected during the COVID-19 pandemic, when screen time generally increased, we expected that (5) video chats and the instrumental use of media to educate and amuse children would be associated with positive communicative developmental outcomes. This hypothesis is based on research that shows that online communication through screens served an important function during the COVID-19 quarantine, providing opportunities for interaction, support, and communication among parents, infants, and distant relatives and friends (Roche et al., 2022; Strouse et al., 2021).

We included in our assessment of digital media use both traditional media, such as television, DVDs, and computers, and contemporary mobile technology, such as smartphones and tablets, with the intent of obtaining an updated picture of the overall family media ecology and of the infant's cumulative media exposure. Mobile technologies are easier to manipulate

and control as they employ touchscreens. In consideration of the young age of the infants investigated in the present work, special attention was given to motivations for media use, mobile devices, and their use during social interactions. Parents were asked to report the amount of media use, motivations for use (to amuse, educate, calm, or connect), and patterns of use during daily routines with the child (meal, sleep, play, childcare, transportation). Because systematic empirical work on media exposure of infants between 4- and 8-months of age is lacking, we recognize that this study is exploratory, and we therefore tested across a range of cognitive and socio-emotional outcomes that had previously been examined in older infants and toddlers.

METHOD

Participants

Participants were 194 4-month-old infants (94 girls; $M = 4.06$, $SD = .26$) recruited from childcare centers, pediatricians' offices, social media networks, and through the newsletter of the "Uppa" Magazine. The inclusion criteria were: to be born after the 37th gestational week, to have typical development, and not to be bilingual (all children were monolingual Italian-learning, not systematically exposed to a second language throughout the day). Most of the infants in the initial sample ($N = 187$) were tested again at 8 months of age (92 girls; $M = 8.04$, $SD = .30$). Seven mothers of the initial sample were not able to complete the questionnaires required within the time frame set in the second phase of the project.

Measures

Demographic Information. Mothers provided demographic information, including infant's date of birth, gender, presence of siblings in the household, and their own level of education. See Table 1.

Media Questionnaire. Mothers of 4- and 8-month-olds completed a subset of questions derived from the Media Assessment Questionnaire (Barr et al., 2020; Bellagamba et al., 2021), a comprehensive assessment of family media exposure during early childhood. Specifically, we focused on the following topics that had been identified previously as correlates of language and developmental outcomes in older toddlers and children: maternal media use, infant media exposure, use of digital devices during everyday child routines, motivations for media use and background television.

Table 1. Children temperament and demographic characteristics of the sample.

Variable	4-month-olds *N*	*M* (*SD*)	8-month-olds *N*	*M* (*SD*)
Surgency/extraversion IBQ-R	194	3.77 (.73)		
Negative affectivity IBQ-R	194	3.24 (.79)		
Orienting regulation IBQ-R	194	5.04 (.62)		
Siblings	194	.47 (.65)	187	.46 (.66)
Mother hours employed in home	194	1.92 (6.43)	186	7.17 (11.11)
Mother hours employed out of home	194	2.19 (7.16)	186	9.29 (11.94)
Mother hours employed total	194	4.03 (10.14)	186	16.46 (15.76)
Mother education	194		186	
Primary and middle school		1 (.5%)		1 (.5%)
High school		21 (10.9%)		18 (9.7%)
University and over		171 (88.6%)		167 (89.8%)

Note. IBQ-R = Infant Behavior Questionnaire—Revised

Maternal Media Use. Mothers answered questions assessing their own media use. We asked: "Thinking about yourself on a typical weekday (Monday-Friday), how often do you personally do each of the following activities at home? (1) Watch TV or DVDs, (2) Use computer, (3) Read electronic books, (4) Read traditional paper books, (5) Listen to music, (6) Play video games on a console game player, (7) Use an iPad, iTouch, or similar device (not including your smartphone), (8) Use a smartphone for things like texting, playing games, watching videos, checking e-mail, or surfing the Internet (do not count time spent talking on the phone)." Mothers chose from the following options: not at all, < 30 min, 30–60 min, 1 - 2 h, 2 - 3 h, 4–5 h, > 5 h. We transformed the ordinal responses into min, by assigning the median time value for each interval: e.g., 0, 15, 45, 90, 150, 270, 330. We then created two composite scores: (1) Reading time (mother), corresponding to the time mothers spent reading (either paper or electronic books) on a typical day (sum of responses obtained in 3, 4, and 5) and (2) Digital media time (mother), corresponding to the time mothers were engaged on digital media (either PC, TV, Tablet or Smartphone) on a typical day (sum of responses obtained in 1, 2, 6, 7, 8).

Infant Media Exposure. Mothers answered questions assessing infant media exposure. We asked: "For the next question, please write "I don't know" if you do not have the information. In the past 2 weeks on a typical weekday how long did your child (1) Watch child-directed TV/videos on any device (tablet, phone, family TV or computer), (2) Videochat (e.g., Facetime or Skype) on any device (e.g., mobile phone or laptop), (3) View or browse traditional books, (4) View or browse electronic books, (5) Listen to an adult reading a book (either paper or electronic), (6) Listen to audiobooks, (7) Listen to music, (8) Play games (e.g., drawing or educational apps) on any device (tablet, smartphone, gaming platform or handheld device), (9) Ask for something to a virtual assistant (e.g., Alexa or Google home)". Mothers chose from the following options: not at all, < 10 min in a day, <30 min in a day,

30–60 min in a day, 1 - 2 h in a day, 2 - 3 h in a day, > 3 h in a day. We transformed the ordinal responses in min by assigning the median time value for each interval: e.g., 0, 5, 15, 45, 90, 150, 210. We then created four composite scores: (1) Music and paper books (infant), corresponding to the time infants spent looking at paper books, listening to an adult reading and listening to music on a typical day in the last 2 weeks (summing responses obtained in 3, 5, and 7); (2) Digital books (infant), corresponding to the time infants spent looking at electronic books and listening to audiobooks on a typical day in the last 2 weeks (summing responses obtained in 4 and 6); (3) Digital media (infant), corresponding to the time infants spent watching TV or DVD, playing games on a device and asking a virtual assistant for something on a typical day in the last 2 weeks (summing responses obtained in 1, 8, and 9); and (4) Videochat (infant), corresponding to the time infants spent communicating through videochat on a typical day in the last 2 weeks (single score in the corresponding item).

Routines. Mothers answered questions assessing their use of digital devices during common daily routines. We asked: "There are often times when parents have to use their smartphone or tablet when spending time with their child. How likely are you to use your phone or other devices (e.g., to make calls, text, check e-mail, watch a video): (1) during meals, (2) getting your child ready for childcare, (3) during playtime, (4) during the bedtime routine, (5) while driving your child to or from activities or when riding on public transportation, (6) while at playgrounds." Responses were collected using a Likert-type scale (I never do this, not very likely, neutral, likely, very likely). We created two measures: (1) DM in Routines, corresponding to the likelihood that mothers use digital devices during daily child routines (summing responses obtained in 2, 3, 4, 5, 6) and (2) DM during meals, corresponding to the likelihood that mothers used digital devices during the mealtime routine (item 1).

Motivations for Media Use. A series of questions investigated the reasons parents used media while engaging with their infants. We asked: "We would like to know how often you use 'media' to do a variety of things for your child. When we say 'media' this includes TV, DVR for recording live televised content, DVDs, personal computer, mobile phone, smartphone, iPad or other tablet, MP3 player, educational game devices, Leapster, console-based gaming systems, virtual personal assistants, etc. How often do you use media (1) to educate my child, (2) to calm my child down when they are upset, (3) to keep my child busy while I get things done, (4) to communicate with family and friends, (5) to let my child enjoy media device, (6) to entertain my child during the meal." Mothers responded using a Likert scale (never, less than once per week, about once per week, 2–3 times per week, 4–6 times per week,

every day, several times per day). We used four measures: (1) Educate and amuse (summing responses obtained in 1 and 5); (2) Busy and calm down (summing responses obtained in 2 and 3); (3) Communicating (item 4); and (4) Entertain during meals (item 6).

Background Media Use. We also collected information regarding background television by asking: "When someone is at home in your household, how often is the TV on, even if no one is actually watching it?" Responses were collected using a Likert type scale (never, hardly ever, some of the time, most of the time, always) and were analyzed as a separate measure (see Table 2).

Temperament. When children were 4 months old, mothers completed the Infant Behavior Questionnaire Revised—Short Form (IBQ-R-SF; Montirosso et al., 2011; Putnam et al., 2014), which measures temperament in infants between 3 and 12 months of age. It assesses 14 dimensions of temperament, which converge into three main scales: Surgency/Extraversion (α = .77), Negative Affectivity (α = .78), and Orienting/Regulation (α = .75). Mothers indicated, on a 7-point Likert scale, ranging from 1 (*Never*) to 7 (*Always*), how often they observed a series of behaviors in the last week (see Table 1).

Developmental Assessment. At both 4 and 8 months of infant age, mothers completed the Italian version of the Developmental Profile TM – 3 (DP – 3; Alpern, 2007; Lanfranchi & Vianello, 2015), a 180-item questionnaire which required them to indicate, on a dichotomous scale (*yes/no*), the presence/absence of a certain behavior in different areas of children's development: Social-Emotional, Cognitive, and Communication (Physical and Adaptive Behavior not used here are described in the Supplementary Materials). The Socio-Emotional Scale (split-half reliability coefficient = .70) measures

Table 2. Media questionnaire variables.

Variable	4-month-olds *N*	4-month-olds *M* (*SD*)	8-month-olds *N*	8-month-olds *M* (*SD*)
Minutes of use per day				
Reading time (mother)	194	108.40 (105.12)	187	93.21 (77.27)
Digital media (mother)	194	262.89 (177.80)	187	263.18 (177.22)
Music and paper books (infant)	177	52.26 (54.24)	163	75.12 (76.93)
Digital books (infant)	189	.37 (2.03)	181	1.16 (5.27)
Digital media (infant)	191	2.28 (8.30)	184	5.35 (13.42)
Videochat (infant)	188	2.34 (4.81)	184	4.92 (9.52)
DM in routines	194	2.90 (2.58)	187	3.92 (2.98)
DM during meals	194	1.09 (1.05)	187	.71 (.78)
Likert scale ratings (1–5)				
Educate and amuse	194	1.14 (3.46)	187	1.41 (3.54)
Busy and calm down	194	2.00 (4.64)	187	2.22 (4.50)
Communicating	194	3.40 (4.57)	187	3.86 (4.43)
Entertain during meals	194	.32 (1.84)	187	.48 (2.02)
Background TV	194	1.21 (1.05)	187	1.05 (1.08)

children's ability in interpersonal relationships, social and emotional sensitivity, and their appropriate behaviors in social situations; specifically, the scale evaluates the way children relate to friends, relatives, and adults (e.g., "When he/she is angry or frustrated, does human touch help him/her to calm down?"; "Is he/she looking at an adult while the adult is talking, as if he/she is trying to follow what the adult is saying?"). The Cognitive Scale (split-half reliability coefficient = .68) measures cognitive abilities useful for effective academic and intellectual functioning. At younger ages, the scale assesses prerequisite skills for academic functioning in areas such as reading, writing, arithmetic, use of computer, and logic (e.g., "When given an object in hand, does he/she pay attention to it for at least 5 seconds?"; "Is he/she looking in the right place for an object that has been moved out of sight?"). The Communication Scale (split-half reliability coefficient = .72) measures expressive and receptive communication skills involving both verbal and non-verbal language. The use and understanding of spoken, written, and gestural language are evaluated together with the ability to use communication tools effectively. Some items measure receptive language (e.g., "Does he/she usually direct his/her gaze towards the source of a sound when it starts?"; "Does he/she clearly understand the meaning of 'no'?"), others evaluate expressive language (e.g., "Does he/she vocalize or use some sounds in order to imitate spoken language or words, as if he/she is pretending to speak?"; "Does he/she communicate, through words or gestures, the idea of 'wanting more' or 'wanting another'?").

The DP-3 provided separate standardized scores for each scale and a General Development score (split-half reliability coefficient = .91), according to infants' age (see Table 3).

Table 3. Development and language variables.

Variable	4-month-olds *N*	*M* (*SD*)	minimum-maximum	8-month-olds *N*	*M* (*SD*)	minimum-maximum
Physical scale score DP3	194	94.82 (17.20)	61–130	188	101.85 (14.88)	75–130
Adaptive behavior scale score DP3	194	90.04 (16.03)	57–130	188	97.97 (19.69)	56–130
Socio-emotional scale score DP3	194	95.76 (14.07)	58–130	188	96.58 (14.32)	52–130
Cognitive scale score DP3	194	93.24 (15.73)	57–130	188	98.67 (14.51)	62–130
Communicate scale score DP3	194	91.20 (13.77)	56–130	188	97.05 (14.08)	63–130
General developmental score DP3	194	90.07 (16.26)	57–139	188	97.71 (17.95)	60–140
Language understanding score MCDI-SF				184	9.40 (12.68)	0–100
Language production score MCDI-SF				186	.16 (.53)	0–14
Gesture score MCDI-SF				188	2.19 (1.66)	0–8

Note. DP3 = Developmental Profile 3. MCDI-SF = MacArthur-Bates Communicative Development Inventory—Short Form.

Language Assessment. When children were 8 months old, mothers completed the Italian version of the MacArthur—Bates Communicative Development Inventory (MCDI—SF): Words and Gestures—Short Form (Fenson et al., 2000)—Il Primo Vocabolario del Bambino: Gesti e Parole—Forma Breve (Caselli et al., 2015). This instrument investigates the communicative and linguistic skills in children aged 8 to 18 months; specifically, mothers were asked to mark which words their children were able to understand and/or say choosing from a list of 100 words and which gestures they produced from a list of 18 gestures (Table 3).

Plan of Analyses

We estimated the associations between media use (maternal use and infant media exposure) and cognitive and communicative development. To test each of the five hypotheses, we performed a series of multiple linear regressions at both 4 and 8 months. Specifically, we assessed whether there was an association between (1) measures related to infant digital media exposure and DP – 3 standardized scores of socioemotional, cognitive and communicative development and "Language Understanding score" and the "Gesture score" of the MCDI—SF (H1), (2) maternal reading time, mother-child media engagement, parental digital media use during child routines, background Tv on and DP – 3 standardized score of communicative development and "Language Understanding score" and the "Gesture score" of the MCDI—SF (H2, H3, H4), (3) videochats, the instrumental use of media to educate and amuse and DP – 3 standardized scores of communicative development and "Language Understanding score" and the "Gesture score" of the MCDI—SF (H5).

Furthermore, we performed a logistic regression to assess the relation between the "Language Production score" of the MCDI—SF (considered dichotomously: 1 = producing words, 0 = not producing words) at 8 months of age and measures related to digital media exposure at the same age, to assess all the above-mentioned hypotheses. Outliers (i.e., children with scores of 100 in Language Understanding and children with scores of 9 and 14 in Language Production) were excluded from the analyses.

We used the same analytical approach at 4 months, 8 months, and for the longitudinal analysis. The models were forced to include 12 or 13 measures of media exposure, whereas the backward procedure (p remove = .10) was used to select potential covariates among three measures of infant temperament, gender, presence of siblings, maternal education, and the mean number of hours the mothers worked in a week. We calculated the Variance Inflation Factors (VIFs) for all the independent variables included in the models, and they were all below the value of 5. In addition, in each regression model we compared the variances of residuals between subgroups based on the different values of the dependent variable using the Breusch-Pagan/Cook-Weisberg test

for homoscedasticity. The test was non-significant, thus supporting the homogeneity of residual variances in each specific regression model except for the dependent variable Language understanding of MCDI—SF, both in concurrent and longitudinal analyses. The number of participants with complete data in the multiple linear regressions ranged from 154 to 160, having adequate power to detect the effects of about 13–14 predictors according to the formula "Number of subjects ≥ 50 + 8*number of predictors." All effects with a p value < .05 were considered statistically significant.

RESULTS

Concurrent Associations Between DP – 3 Scores of Socio-Emotional, Cognitive, and Communicative Development and Infant Media Exposure and Maternal Media Use at 4 Months

The overall regression model for the DP − 3 Socio-Emotional score was significant, $F(13, 152) = 2.59$, $p = .003$, $R^2 = .18$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .809$. The DP − 3 Socio-Emotional score was positively related to Digital media (infant), $b = .38$, $p = .035$, $\eta^2 = .03$, which was inconsistent with H1, the instrumental use of media to Educate and amuse, $b = 1.26$, $p = .005$, $\eta^2 = .05$, and Videochat (infant), $b = .46$, $p = .038$, $\eta^2 = .03$, consistent with H5. Not surprisingly, the DP − 3 Socio-Emotional score was also related to the Surgency/Extraversion temperamental dimension, $b = 3.73$, $p = .014$, $\eta^2 = .04$.

The overall regression model for the DP − 3 Cognitive Score was also significant, $F(14, 151) = 1.58$, $p = .09$, $R^2 = .13$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .45$. None of the hypotheses were supported for the DP − 3 Cognitive score, but this score was positively related to the Surgency/Extraversion temperamental dimension, $b = 4.49$, $p = .024$, $\eta^2 = .03$.

The overall regression model for the DP − 3 Communicative score was not significant $F(13, 152) = 1.40$, $p = .167$, $R^2 = .11$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .416$, and again none of the hypotheses were supported. This score was only negatively related to the number of siblings, $b = -4.93$, $p = .015$, $\eta^2 = .04$ (see Table 4 for the full models).

Concurrent Associations Between DP – 3 Scores of Socio-Emotional, Cognitive, and Communicative Development and Infant Media Exposure and Maternal Media Use at 8 Months

The overall regression model for the DP − 3 Socio-Emotional score was not significant, $F(15, 138) = 1.65$, $p = .069$, $R^2 = .15$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .707$. The DP − 3

Table 4. Multiple linear regressions for DP3 domain scores and media exposure at 4 months.

Dependent variable	Physical score		Adaptive behavior score		Social-emotional score		Cognitive score		Communication score		General development score	
Adjusted R^2	.01		.03		.11		.05		.03		.04	
M VIF	1.50		1.50		1.50		1.54		1.50		1.50	
Maximum VIF	2.97		2.97		2.97		3.01		2.83		2.97	
Independent variable	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*
Music and paper books (infant)	−.01 [.06;.05]	.817	−.03 [−.08;.02]	.280	.01 [−.04;.05]	.741	.01 [−.04;.06]	.793	.02 [−.02;.07]	.290	−.001 [−.05;.50]	.997
Digital books (infant)	.09 [−1.17;1.35]	.888	−.09 [−1.26;1.08]	.877	.15 [−.85;1.15]	.764	−.59 [−1.74;.56]	.309	.59 [−.44;1.62]	.257	.09 [−1.10;1.28]	.879
Digital media (infant)	.08 [−.38;.53]	.737	.33 [−.09;.76]	.120	.39 [.03;.75]	.035	.34 [−.08;.75]	.111	.32 [−.05;.69]	.089	.41 [−.02;.84]	.059
Videochat (infant)	.22 [−.33;.76]	.432	.08 [−.43;.58]	.769	.46 [.03;.89]	.038	.39 [−.11;.89]	.122	−.08 [−.53;.37]	.725	.30 [−.22;.81]	.260
Background TV	.77 [−2.12;3.66]	.601	.63 [−2.05;3.32]	.643	−1.22 [−3.51;1.07]	.294	−1.57 [−4.30;1.17]	.259	.46 [−1.88;2.80]	.699	−.08 [−2.82;2.5]	.952
Educate and amuse	−.59 [−1.70;.52]	.294	.65 [−.39;1.68]	.218	1.26 [.38;2.14]	.005	−.20 [−1.22;.83]	.707	.17 [−.73;1.07]	.706	.30 [−.75;1.35]	.571
Busy and calm down	−.09 [−1.03;.86]	.860	−.64 [−1.52;.24]	.154	−.67 [−1.42;.08]	.079	.48 [−.39;1.35]	.277	−.01 [−.76;.74]	.978	−.26 [−1.15;.64]	.574
Communicating	.35 [−.25;.95]	.254	−.07 [−.63;.49]	.809	.24 [−.24;.72]	.325	−.07 [−.62;.49]	.812	.07 [−.42;.56]	.780	.16 [−.41;.73]	.581

(*Continued*)

Table 4. (Continued).

Dependent variable	Physical score		Adaptive behavior score		Social-emotional score		Cognitive score		Communication score		General development score	
Reading time (mother)	.02 [−.01;.05]	.250	.01 [−.02;.04]	.331	.5 [−.02;.03]	.646	−.001 [−.03;.03]	.920	−.01 [−.04;.02]	.418	.01 [−.02;.04]	.619
Digital media (mother)	.001 [−.02;.02]	.899	.01 [−.01;.02]	.556	−.01 [−.02;.001]	.177	−.001 [−.02;.02]	.892	.001 [−.01;.02]	.916	−.001 [−.02;.02]	.888
Digital Media during meals	−1.11 [−3.73;1.51]	.405	−1.57 [−4.00;.87]	.206	−1.67 [−3.75;.40]	.113	−.31 [−2.71;2.09]	.799	−1.16 [−3.34;1.02]	.293	−1.54 [−4.02;.94]	.221
Digital Media in routines	.21 [−.94;1.35]	.72	−.36 [−1.43;.70]	.50	−.63 [−1.53;.28]	.171	−.63 [−1.77;.56]	.237	−.02 [−1.11;.79]	.738	−.46 [−1.55;.62]	.397
Surgency/extraversion	5.15 [1.39;8.90]	.01	5.28 [1.79;8.77]	.001	3.73 [.76;6.70]	.014	4.49 [.60;8.38]	.024	–		5.30 [1.75;8.85]	.004
Negative affectivity	–		–		–		–		–		–	
Orienting regulation	–		–		–		−4.51 [−9.27;.25]	.063	–		–	
Gender	–		–		–		–		–		–	
Siblings	–		–		–		–		−4.93 [−8.90;-.96]	.015	–	

Note. VIF = Variance inflation factor. [95% CI] - lower and upper bound of 95% confidence interval.

Socio-Emotional score was positively related to the instrumental use of media for Communicating, $b = 0.62$, $p = .030$, $\eta^2 = .03$, which was consistent with H5, and to the Surgency/Extraversion temperamental dimension, $b = 5.12$, $p = .004$, $\eta^2 = .06$; moreover, this score was inversely related to the Negative Affectivity temperamental dimension, $b = -3.56$, $p = .024$, $\eta^2 = .04$.

The overall regression model for the DP − 3 Cognitive score was significant, $F(15, 138) = 1.94$, $p = .024$, $R^2 = .17$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .562$. The DP − 3 Cognitive score was positively related to the Surgency/Extraversion temperamental dimension, $b = 3.99$, $p = .024$, $\eta^2 = .04$, and negatively related to the number of siblings, $b = -6.87$, $p = .002$, $\eta^2 = .07$, but none of our hypotheses were supported.

Finally, the overall regression model for the DP − 3 Communicative score was not significant, $F(13, 140) = 1.46$, $p = .141$, $R^2 = .12$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .375$. The DP − 3 Communication score was positively associated with the instrumental use of media for Communicating, $b = .61$, $p = .033$, $\eta^2 = .03$, consistent with H5, and with Digital books (infant), $b = .42$, $p = .047$, $\eta^2 = .03$, consistent with H2 (see Table 5 for the full model).

Concurrent Associations Between MCDI-SF Scores and Infant Media Exposure and Maternal Media Use at 8 Months

The overall regression model for the Language Understanding score of the MCDI—SF was significant, $F(17, 137) = 2.32$, $p = .004$, $R^2 = .13$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p < .001$. The Language Understanding score was inversely related to the variable DM in Routines, $b = -1.07$, $p = .039$, $\eta^2 = .03$, consistent with H3.

The overall regression model for the Gesture score of the MCDI—SF was significant, $F(16, 138) = 2.47$, $p = .002$, $R^2 = .13$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .053$. The Gesture score was positively related to the variables Music and paper books (infant), $b = .01$, $p = .037$, $\eta^2 = .03$, and Digital books (infant), $b = .05$, $p = .049$, $\eta^2 = .03$, consistent with H2, whereas it was negatively associated with the variable Digital media time (mother), $b = -.002$, $p = .023$, $\eta^2 = .04$, consistent with H3. The Gesture score was also inversely associated with the temperamental dimension Surgency/Extraversion, $b = .58$, $p = .004$, $\eta^2 = .06$ (see Table 6 for the full model).

The logistic regression for the Language Production score was significant, $\chi^2(16) = 35.58$, $p = .003$, $R^2 = .33$. This score of the MCDI—SF was positively related to the variables Music and paper books (infant), $OR = 1.02$, $SE = .01$, $p = .013$, consistent with H2, and negatively related to Reading time (mother), $OR = .99$, $SE = .01$, $p = .034$, partially consistent with H3. The Language Production score was also positively related to the Surgency/extraversion

Table 5. Multiple linear regressions for DP3 domain scores and media exposure at 8 months.

Dependent variable	Physical score		Adaptive behavior score		Social-emotional score		Cognitive score		Communication score		General development score	
Adjusted R2	−.02		.05		.06		.09		.04		.40	
M VIF	1.55		1.58		1.55		1.55		1.59		1.55	
ggMaximum VIF	2.77		2.90		2.79		2.91		2.77		2.91	
Independent variable	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*
Music and paper books (infant)	.01 [−.04;.05]	.814	.01 [−.05;.07]	.767	.001 [−.04;.05]	.868	.03 [−.02;.07]	.199	−.03 [−.07;.02]	.227	.01 [−.05;.06]	.782
Digital books (infant)	.29 [−.16;.74]	.201	.08 [−.49;.64]	.794	.38 [−.03;.79]	.072	.91 [−.33;.52]	.672	.42 [−.01;.83]	.047	.34 [−.44;.19]	.212
Digital media (infant)	−.01 [−.28;.26]	.933	−.11 [−.45;.23]	.528	−.18 [−.42;.07]	.151	−.03 [−.28;.22]	.802	−.15 [−.39;.10]	.237	−.12 [−.44;.19]	.451
Videochat (infant)	.17 [−.34;.37]	.924	.29 [−.15;.74]	.194	.03 [−.29;.35]	.848	.21 [−.12;.54]	.215	.17 [−.16;.49]	.307	.19 [−.23;.60]	.372
Background TV	−.55 [−3.00;1.89]	.656	−.32 [−3.37;2.74]	.838	1.35 [−.92;3.62]	.241	−.61 [−2.92;1.71]	.605	.55 [−1.68;2.78]	.625	−.22 [−3.11;2.67]	.880
Educate and amuse	−.81 [−1.93;.32]	.161	−.42 [−1.84;1.00]	.556	.28 [−.75;1.30]	.595	.34 [−.72;1.40]	.523	−.46 [−1.49;.57]	.375	−.22 [−1.55;1.10]	.740
Busy and calm down	.60 [−.47;1.67]	.268	.34 [−1.01;1.70]	.618	.22 [−.75;1.19]	.653	−.47 [−1.48;.55]	.365	.74 [−.23;1.71]	.134	.27 [−1.00;1.54]	.676
Communicating	.33 [−.28;.95]	.285	.31 [−.46;1.07]	.431	.62 [.06;1.17]	.030	.15 [−.42;.72]	.598	.61 [−.05;1.17]	.033	.54 [−.18;1.25]	.138

(*Continued*)

Table 5. (Continued).

Dependent variable	Physical score		Adaptive behavior score		Social-emotional score		Cognitive score		Communication score		General development score	
Entertaining during meals	−.78 [−3.32;1.76]	.546	.45 [−2.71;3.61]	.780	−1.12 [−3.42;1.18]	.338	.85 [−1.52;3.21]	.482	.50 [−1.81;2.82]	.667	−.05 [−3.01;2.91]	.973
Reading time (mother)	−.00 [−.04;.04]	.901	.04 [−.01;.09]	.123	.03 [−.01;.06]	.176	−.02 [−.06;.02]	.288	.03 [−.00;.06]	.153	.02 [−.03;.06]	.492
Digital media (mother)	.01 [−.01;.03]	.233	.01 [.01;.03]	.247	.00 [−.01;.06]	.612	.01 [−.00;.03]	.148	−.01 [−.02;.01]	.292	.01 [−.01;.03]	.347
Digital media during meals	−.34 [−3.82;3.14]	.848	−.17 [−4.50;4.16]	.937	−.89 [−4.06;2.28]	.581	.02 [−3.22;3.25]	.991	.09 [−3.09;3.26]	.958	−.23 [−4.27;3.82]	.911
Digital Media in routines	−.47 [−1.43;.50]	.339	−.03 [−1.25;1.89]	.963	.40 [−.49;1.29]	.372	−.54 [−1.45;.37]	.242	−.28 [−1.16;.60]	.527	−.22 [−1.35;.92]	.708
Surgency/extraversion	–		–		5.12 [1.65;8.59]	.004	3.99 [.537;7.44]	.024	–		3.57 [−.74;7.88]	.104
Negative affectivity	–		–		−3.56 [−6.63;.49]	.024	–		–		–	
Orienting regulation	–		–		–		–		–		–	
Gender	3.86 [−1.13;8.85]	.128	–		–		–		–		–	
Siblings	–		−7.51 [−13.22;-1.81]	.010	–		−6.87 [−11.14;-2.60]	.002	–		−6.07 [−11.41;-.74]	.026
Mother education	–		–		–		–		–		–	
Mother hours employed total	–		–		–		–		–		–	

Note. VIF= Variance inflation factor. [95% CI] - lower and upper bound of 95% confidence interval.

Table 6. Multiple linear regressions for communicative and linguistic development at 8 months.

Dependent variable	Language understanding score		Gesture score	
Adjusted R2	.127		.133	
M VIF	1.68		1.68	
Maximum VIF	3.81		3.63	
Independent variable	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*
Music and paper books (infant)	.03 [−.01;.08]	.153	.01 [.00;.01]	.037
Digital books (infant)	−.01 [−.48;.45]	.961	.05 [.00;.09]	.049
Digital media (infant)	.09 [−.17;.36]	.487	.00 [−.03;.03]	.890
Videochat (infant)	.13 [−.23;.50]	.479	.01 [−.03;.05]	.607
Background TV	−.34 [−2.91; 2.23]	.795	−.15 [−.41;.11]	.245
Educate and amuse	−.69 [−1.82;.45]	.235	−.07 [−.18;.04]	.195
Busy and calm down	.38 [−.74;1.49]	.506	.10 [−.01;.21]	.073
Communicating	.40 [−.23;1.03]	.210	.01 [−.03;.07]	.755
Entertaining during meals	−.30 [−2.67;2.208]	.806	−.11 [−.35;.13]	.347
Reading time (mother)	−.02 [−.07;.02]	.245	−.00 [−.01;.00]	.517
Digital media (mother)	.01 [−.01;.03]	.202	−.00 [−.001; −.001]	.023
Digital Media during meals	−.85 [−4.40;2.70]	.638	−.09 [−.45;.26]	.602
Digital Media in routines	−1.07 [−2.09; −.05]	.039	−.04 [−.14; .06]	.397
Surgency/extraversion	3.64 [−.27;7.56]	.068	.58 [.19;.97]	.004
Negative affectivity	−3.13 [−6.60;.34]	.076	−.28 [−.63;.07]	.111
Orientation regulation	–		–	
Gender	–		–	
Siblings	−4.42 [−9.17;.33]	.068	–	
Mother education	−10.05 [−20.13;.04]	.051	.85 [−.14;1.85]	.092
Mother hours employed total	–		–	

Note. VIF = Variance inflation factor. [95% CI] - lower and upper bound of 95% confidence interval.

temperamental dimension, $OR = 6.47$, $SE = 4.13$, $p = .003$, and to the Orienting/Regulation temperamental dimension, $OR = .18$, $SE = .13$, $p = .019$, and unexpectedly to maternal education, $OR = .08$, $SE = .08$, $p = .015$ (see Table 7).

Longitudinal Relations Between Media Variables at 4 Months of Age and Developmental Outcomes at 8 Months of Age

The overall regression model for the DP − 3 Socio-Emotional score was significant, $F(14, 144) = 2.00$, $p = .021$, $R^2 = .16$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .705$. The Socio-Emotional score

Table 7. Logistic regression for "production language score" at 8 months.

Variable	Coefficient	Standard error	*p*-value	OR	[95% CI]
Music and paper books (infant)	2.47	.01	.013	1.02	[1.003,1.029]
Digital books (infant)	1.82	.10	.068	1.17	[.988,1.387]
Digital media (infant)	.27	.06	.789	1.02	[.905,1.140]
Videochat (infant)	−.72	.04	.469	.97	[.899,1.050]
Background Tv	.18	.38	.856	1.07	[.533,2.130]
Educate and amuse	−.94	.35	.350	.56	[.166,1.890]
Busy and calm down	−.42	.16	.672	0.93	[.672,1.292]
Communicating	.70	.08	.484	1.06	[.907,1.228]
Entertaining during meals	−1.82	.05	.069	.03	[.000,1.328]
Reading time (mother)	−2.12	.01	.034	.99	[.971,.999]
Digital media (mother)	1.07	.001	.285	1.00	[.998,1.006]
Digital Media during meals	−.47	.38	.636	.80	[.310,2.044]
Digital Media in routines	.33	.13	.744	1.04	[.813,1.336]
Surgency/extraversion	2.92	4.13	.003	6.47	[1.851,22.620]
Orientation regulation	−2.35	.13	.019	.18	[.043,.753]
Mother education	−2.44	.08	.015	.08	[.010,.609]

Note. OR—Odds ratio. [95% CI] - lower and upper bound of 95% confidence interval.

was positively associated with the Surgency/Extraversion temperamental dimension, $b = 5.41$, $p = .001$, $\eta^2 = .07$, whereas it was negatively related to the Negative Affectivity temperamental dimension, $b = -3.50$, $p = .032$, $\eta^2 = .03$. None of our hypotheses were supported.

Similarly, the overall regression model for the DP − 3 Cognitive score was significant, $F(14, 144) = 2.53$, $p = .003$, $R^2 = .20$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .710$. The DP − 3 Cognitive score was positively associated with the instrumental use of media to Educate and Amuse, $b = 1.38$, $p = .011$, $\eta^2 = .04$, consistent with H5. Once again, the DP − 3 Cognitive score was positively associated with the Surgency/Extraversion temperamental dimension, $b = 4.37$, $p = .008$, $\eta^2 = .05$, and negatively associated with the number of siblings, $b = -5.64$, $p = .008$, $\eta^2 = .05$.

The overall regression model for the DP − 3 Communicative score was not significant, $F(12, 146) = 1.41$, $p = .166$, $R^2 = .10$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .328$. There was, however, a negative association between the DP − 3 Communicative score and Digital media (infant), $b = -.76$, $p = .021$, $\eta^2 = .04$, consistent with H1, and a positive relation with the variable TV On (Background media use), $b = 3.55$, $p = .006$, $\eta^2 = .05$, inconsistent with H4.

The overall regression model for the MCDI—SF Language Understanding score was significant, $F(17, 140) = 2.34$, $p = .004$, $R^2 = .22$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p < .001$. The Language Understanding score was positively related to the Surgency/Extraversion temperamental dimension, $b = 3.72$, $p = .013$, $\eta^2 = .04$, and negatively related to the Negative Affectivity temperamental dimension, $b = -3.11$, $p = .032$, $\eta^2 = .03$, and with the number of siblings, $b = -4.90$, $p = .007$, $\eta^2 = .05$. None of our hypotheses were supported.

The overall regression model for the MCDI—SF Gesture score was not significant, $F(15, 144) = 1.34$, $p = .184$, $R^2 = .13$, Breusch—Pagan/Cook—Weisberg test for heterogeneity of residual variances $p = .081$. There was, however, a positive relation with the Surgency/Extraversion temperamental dimension, $b = .51$, $p = .008$, $\eta^2 = .05$, and a negative relation with the number of siblings, $b = -.47$, $p = .046$, $\eta^2 = .03$ (see Tables 8 and 9 for the full models).

The logistic regression model for MCDI—SF Language Production was significant, $\chi^2(14) = 28.08$, $p = .014$, $R^2 = .24$. This score was positively associated with the media variable Reading time (mother), $OR = 1.01$, $SE = .003$, $p = .025$, consistent with H3, and with the Surgency/Extraversion temperamental dimension, $OR = 4.72$, $SE = 2.63$, $p = .005$, whereas it was inversely related to the Negative Affectivity and Orientation Regulation temperamental dimensions, respectively, $OR = .31$, $SE = .15$, $p = .018$; $OR = .18$, $SE = .12$, $p = .010$ (see Table 10). No other significant relations were found.

DISCUSSION

The present study investigated the concurrent and longitudinal associations between screen exposure and developmental outcomes at 4 and 8 months of age. The DREAMER framework (Barr et al., 2024) was tested, and the findings demonstrated that the motivations for media use (e.g., to connect or amuse), the content and context in which media were used by parents and infants (e.g., media use during routines versus joint reading) along with individual characteristics (e.g., temperament) were associated with children's socioemotional, communicative, and language outcomes. In addition, the longitudinal findings showed cumulative effects of daily decisions about media and use of media within the family media ecology on developmental outcomes.

Associations Between Infant Media Exposure and DP – 3 Profiles

As young as 4 months of age, the time infants spent viewing digital content on different devices, such as TV or tablets, the use of media with the intent of educating and amusing them and the time infants spent communicating through videochat were related to their higher scores on the Socio-emotional scale consistent with H5. In addition, the use of media to educate and amuse children at 4 months of age was positively related to their cognitive score at 8 months. These findings suggest that the motivations for using media (i.e., to amuse and educate children) have important implications for children's development.

Longitudinal analysis also showed that greater media exposure at 4 months was associated with worse communication outcomes at 8 months which was consistent with H1. Thus, solo viewing of media at 4 months may be detrimental to infant communicative abilities. Future research is needed to further explore relations between use, type, and motivations of media use during early

Table 8. Multiple linear regressions for media variables at 4 months of age and DP-3 outcomes at 8 months of age.

Dependent variable	Physical Score		Adaptive Behavior Score		Social-Emotional Score		Cognitive Score		Communication Score		General Development Score	
Adjusted R2	.03		.06		.08		.12		.03		.08	
M VIF	1.41		1.41		1.44		1.41		1.43		1.41	
Maximum VIF	2.52		2.52		2.71		2.52		2.43		2.52	
Independent variable	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*
Music and paper books (infant)	.04 [.04;.05]	.870	.01 [−.05;.07]	.670	.02 [−.02;.06]	.376	.03 [−.01;.08]	.152	.02 [−.03;.06]	.402	.03 [−.03;.08]	.378
Digital books (infant)	1.23 [−.14;2.31]	.027	1.20 [−.25;2.65]	.103	.88 [−.14;1.90]	.091	.84 [−.20;1.89]	.113	.96 [−.09;2.01]	.072	1.38 [.06;2.69]	.041
Digital media (infant)	−.02 [−.69;.64]	.946	−.46 [−1.35;.43]	.310	−.26 [−.89;.37]	.415	−.59 [−1.23;.05]	.072	−.76 [−1.40;-.12]	.021	−.57 [−1.38;.24]	.165
Videochat (infant)	.30 [−.18;.78]	.224	.16 [−.49;.80]	.633	.27 [−.18;.72]	.239	.11 [−.36;.58]	.641	.03 [−.44;.49]	.912	.23 [−.35;.82]	.432
Background Tv	.48 [−2.13;3.10]	.715	1.91 [−1.57;5.39]	.279	1.49 [−.98;3.95]	.235	1.31 [−1.20;3.839]	.304	3.55 [1.03;6.07]	.006	2.55 [−.61;5.72]	.113
Educate and amuse	.41 [−.61;1.43]	.425	.84 [−.52;2.20]	.226	.75 [−.24;1.73]	.137	1.28 [.30;2.27]	.011	.79 [−.20;1.77]	.116	1.22 [−.01;2.46]	.053
Busy and calm down	−.90 [−1.76;.04]	.041	−.72 [−1.87;.42]	.213	−.25 [−1.09;.58]	.550	−.55 [−1.38;.28]	.192	.09 [−.73;.90]	.837	−.75 [−1.79;.30]	.159
Communicating	.26 [−.27;.79]	.327	.35 [−.35;1.05]	.322	.31 [−.20;.81]	.230	.36 [−.15;.87]	.162	−.09 [−.59;.42]	.0731	.31 [−.33;.95]	.334

(*Continued*)

Table 8. (Continued).

Dependent variable	Physical Score		Adaptive Behavior Score		Social-Emotional Score		Cognitive Score		Communication Score		General Development Score	
Reading time (mother)	.001 [−.03;.03]	.877	.00 [−.04;.04]	.928	.02 [−.01;.04]	.248	−.01 [−.04;.02]	.585	.01 [−.02;.03]	.576	.001 [−.03;.04]	.826
Digital media (mother)	.01 [−.01;.02]	.316	.01 [−.01;.03]	.291	−.01 [−.02;.01]	.496	−.001 [−.02;.01]	.968	−.001 [−.02;.01]	.982	.001 [−.02;.02]	.743
DM during meals	−.92 [−3.22;1.38]	.429	−1.90 [−5.02;1.22]	.231	.11 [−2.05;2.28]	.917	.23 [−2.03;2.48]	.844	−.29 [−2.51;1.93]	.797	−.96 [−3.80;1.88]	.504
DM in routines	.43 [−.58;1.44]	.398	.37 [−1.01;1.75]	.600	−.05 [−1.00;.89]	.911	.43 [−.57;1.43]	.395	.39 [−.58;1.36]	.428	.52 [−.74;1.77]	.417
Surgency/extraversion	3.14 [−.17;6.45]	.063	4.35 [−.59;8.75]	.053	5.41 [2.17;8.65]	.001	4.37 [1.19;7.56]	.008	–		500. [.99;9.00]	.015
Negative affectivity	–		–		−3.50 [−6.14;.05]	.032	–		–		–	
Orientation regulation	–		–		–		–		–		–	
Siblings	–		−7.40 [−13.10;-1.71]	.011	–		−5.64 [−9.75;-1.52]	.008	–		−5.11 [−10.29;.07]	.053

Note. VIF = Variance inflation factor. [95% CI] - lower and upper bound of 95% confidence interval.

Table 9. Multiple linear regressions for media variables at 4 months of age and MCDI-SF outcomes at 8 months of age.

Dependent variable	Language understanding score		Gesture score	
Adjusted R2	.127		.031	
M VIF	1.50		1.53	
Maximum VIF	3.34		3.32	
Independent variable	Coefficient [95%CI lower; upper]	*p*	Coefficient [95%CI lower; upper]	*p*
Music and paper books (infant)	.02 [−.02;.06]	.218	.001 [−.001;.01]	.384
Digital books (infant)	−.23 [−1.15;.68]	.615	.05 [−.07;.17]	.433
Digital media (infant)	.05 [−.29;.40]	.761	.001 [−.05; .04]	.981
Videochat (infant)	.40 [−.001;.81]	.052	−.01 [−.06;.04]	.724
Background Tv	.20 [−2.00; 2.40]	.859	.23 [−.06;.51]	.119
Educate and amuse	.26 [−.61; 1.12]	.561	−.03 [−.14;.08]	.580
Busy and calm down	.03 [−.71;.77]	.937	.00 [−.09;.10]	.948
Communicating	−.05 [−.52;.41]	.819	−.03 [−.09;.03]	.353
Reading time (mother)	−.01 [−.04;.01]	.252	−.00 [−.00;.00]	.717
Digital media (mother)	.001 [−.01;.01]	.925	−.00 [−.001;.001]	.560
Digital Media during meals	−1.46 [−3.44;.51]	.145	−.17 [−.43;.08]	.187
Digital Media in routines	−.33 [−1.21;.55]	.454	.02 [−.09;.13]	.724
Surgency/extraversion	3.72 [.78;6.66]	.013	.51 [.135;.882]	.008
Negative affectivity	−3.11 [−5.94; −.28]	.032	−.31 [−.67;.06]	.10
Siblings	−4.90 [−8.47; −1.34]	.007	−.47 [−.929;-.009]	.046
Mother education	−4.67 [−11.76;2.43]	.196	–	
Mother hours employed total	.16 [−.04;.35]	.122	–	

Note. VIF = Variance inflation factor. [95% CI] - lower and upper bound of 95% confidence interval.

infancy and infant outcomes. Moreover, given that our data are based on self-reports, future studies should use additional data collection methods.

Associations Between Maternal Media Use and Language Development

The results of testing H2 and H3 showed that how mothers used media when infants were 8 months old had a strong influence also on the onset of their communicative and linguistic development. There were quite consistent patterns across three key aspects of communication: gestures, verbal language comprehension, and verbal language production at a time when infants frequently gesture (Camaioni et al., 2004; Iverson et al., 1999) and at a time when many infants are producing their first words (Bates et al., 1988).

Table 10. Logistic regression for media variables at 4 months of age and "language production score" at 8 months of age.

Variable	Coefficient	Standard error	p-value	OR	[95% CI]
Music and paper books (infant)	1.11	.01	.269	1.01	[1.003,1.029]
Digital media (infant)	−1.21	.10	.224	.87	[.704,1.086]
Videochat (infant)	−.61	.08	.542	.95	[.811,1.116]
Background Tv	−.39	.30	.698	.88	[.452,1.702]
Educate and amuse	−.70	.13	.486	.91	[.166,1.890]
Busy and calm down	1.93	.11	.054	1.20	[.997,1.448]
Communicating	−.65	.08	.517	.95	[.806,1.115]
Reading time (mother)	2.25	.001	.025	1.01	[1.001,1.013]
Digital media (mother)	−.46	.001	.644	1.00	[.996,1.002]
Digital media during meals	−.38	.27	.707	.89	[.487,1.629]
Digital media in routines	1.63	.14	.103	1.21	[.963,1.517]
Surgency/extraversion	2.78	2.63	.005	4.72	[1.579,14.084]
Orientation regulation	−2.57	.12	.010	.18	[.048,.663]
Negative affectivity	−2.36	.15	.018	.31	[.114,.818]

Note. OR—Odds ratio. [95% CI] - lower and upper bound of 95% confidence interval.

We found that the time infants spent looking at traditional and electronic books, and listening to an adult reading a traditional paper book, to music, and to audiobooks on a typical day in the previous 2 weeks was positively associated with infant gestures and with producing their first words. Not surprisingly, the infant's first gestural and vocal vocabulary are usually positively related to the daily time parents dedicate to pleasurable activities, such as joint reading (Sundqvist et al., 2021). Traditional paper book reading and listening to music are both ways of engaging with the infant during play. The role of music in language development has often been neglected despite research that has shown that an enriched musical environment during infancy can promote the development of communication skills (Papadimitriou et al., 2021) and that music training can have a positive impact on phonological processing, inhibitory control, and motor skills in kindergarten (Bolduc et al., 2021). Similarly, digital books and audio books may positively enrich the infant's environment (Sari et al., 2019). Longitudinal analyses revealed a positive relation between the time spent by mothers reading when their infants were 4 months old and language production at 8 months of age, consistent with our hypothesis. This result is in line with the literature, because mothers who love reading will presumably read earlier to their children (Oliver et al., 2005). Ways to enhance these positive activities should be further investigated because, although most parents own smartphones, digital inequity among families from different social backgrounds, resulting in different access to appropriate devices and connections, continues (Barr, 2022), and devising and disseminating new smart apps for families that promote joint engagement, particularly for families with low resources, are needed.

However, our results also highlighted negative associations between (1) maternal use of digital media on a typical day and infant gesture production,

(2) maternal use of digital media during daily infant routines and infant language comprehension, and (3) the likelihood of mothers reading either paper or electronic books and infant language production. All these activities may have reduced the frequency of language interactions between infants and their mothers. These results accord with previous work with slightly older children by Sundqvist et al. (2021), who found that children's vocabulary and grammar were negatively associated with the likelihood of parents' use of digital devices during routines at 2 years of age. The current study demonstrates that disruptions to language may start during the first year of life. Disruption of ongoing interactions due to parental media usage have been termed "technoference" (McDaniel & Radesky, 2018). Considering that routines organize joint activities that have a clear common goal, such as dressing, eating, or reading, high levels of absorption of caregiver attention with media during daily routines may disrupt and interfere with the infant's emergent abilities for social referencing and joint attention. When checking their smartphone, adults usually have a neutral face, with no emotional expression (Konrad et al., 2021), and such expressions may be perceived by children as distant and not available for sharing and communicating. Mothers who spend a lot of time during the day on digital media may be very absorbed by this activity and, even without being aware of that, may dedicate less attention and communicative exchanges to their infant, with a possible negative impact on the infant's understanding that people are intentional agents and can communicate using gestures and words (Tomasello et al., 2005).

Associations Between Background TV on and DP – 3 Communicative Development Score

Regarding our H4, the longitudinal data showed an unexpected result: the positive relation between the background use of television during the day at 4 months and the DP – 3 communicative score at 8 months. The findings regarding background television are puzzling as, based on the literature (Barr et al., 2010; Kirkorian et al., 2019), we expected that greater use of background television at 4 months would link with a lower communicative score at 8 months. However, the effect of background television has not yet been investigated at this developmental timepoint. It is possible that background television serves a different function at very young ages. For example, we hypothesize that the effect of background television at 4 months, such as keeping television on during breastfeeding, may have supported ongoing breastfeeding which was indirectly related to a better communicative development (Coyne et al., 2022).

Associations Between Video-Chats and DP – 3 Communicative Development Score

Finally, investigation of the relation between video-chats and communicative development showed that, consistent with H5, at 8 months of age looking at screens with the infants for the purpose of communicating with familiar persons (friends and relatives) distant in space was positively associated with infants' socio-emotional and communicative development. Studies have documented that during the COVID – 19 pandemic video chat supported connections between young children and relatives in enjoyable and creative ways, promoting their bonding, health, and well-being (Roche et al., 2022; Strouse et al., 2021). In contrast to prerecorded videos, video chats provide opportunities to interact contingently with children, and infants learn more effectively from video chat than they learn from prerecorded videos (Myers et al., 2017). This result extends to a very early age the likely positive impact that contingent interaction on a video can have on language development (McClure et al., 2015; Myers et al., 2024).

Limitations and Strengths

Some limitations to this study deserve note. First, we relied on maternal reports that may be subject to recall and social desirability biases. To limit this effect, questions requiring mothers to estimate time of infant exposure to media were asked in relation to the previous 2 weeks to enhance accuracy and reduce memory biases (Vandewater & Lee, 2009). Despite a lack of direct observational measures, the maternal reports used in the present work are considered valid and reliable (Heilmann et al., 2005; Putnam et al., 2006). Second, our data were collected during the COVID – 19 pandemic, when many families may have relied on media much more than in non-emergency periods, so we cannot exclude that mothers overestimated typical infant media exposure. Irrespective of these limitations, our study has several strengths, including a large sample of typically developing infants, an investigation about media exposure as early as 4 months of age, and a detailed investigation of the content and context of media exposure in the first year of life, with potentially long-lasting effects on infants' later cognitive and linguistic development. Furthermore, because the data were collected as part of a larger longitudinal study and we based our analyses on the DREAMER framework, we included temperament and sibling status as controls in our models testing the family media ecology. Several associations between temperamental dimensions and number of siblings with developmental outcomes emerged. Although not our primary focus, future research should continue to examine interactions between temperament and siblings and media usage patterns as well as their combined effects on developmental outcomes.

IMPLICATIONS FOR PRACTICE AND THEORY

The results of the current work extend and strengthen prior findings to younger infants in Italy. The ways in which parents use screens with infants play an important role in children's development. On the positive side, engaging infants when using screens for communicating via video chat, both at 4 and 8 months of age, was positively related with infant development, as this activity, supported by parents, may be both meaningful and motivating for the infant. Moreover, time dedicated to reading books with the infant (either electronic or paper book) was also positively associated with infant development. On the negative side, the amount of time spent at 4 and 8 months on a typical day on a device, likely a solo activity, and the parent's overall usage and usage of digital media during childhood routines were negatively associated with infant communicative and linguistic skills. Consistent with the complexity of the digital media landscape, these results highlight the potentially positive and negative impacts of very early digital media exposure and test the DREAMER framework. This longitudinal study is ongoing, and future reports will examine trajectories of these infants through the end of their second year of life.

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Ethical Principles

The authors affirm having followed professional ethical guidelines in preparing this work. These guidelines include obtaining informed consent from human participants, maintaining ethical treatment and respect for the rights of human or animal participants, and ensuring the privacy of participants and their data, such as ensuring that individual participants cannot be identified in reported results or from publicly available original or archival data. This study complied with the APA Ethical Guidelines and was approved by the Ethics Committees of the Department of Dynamic and Clinical Psychology and Health Studies of Sapienza University of Rome (Prot. n. 000April 14, 315, 2020 and n. 000December 15, 1209, 2020) and by the National Research Council of Italy (Prot. n. 0072148October 18, 2019, 2019; Prot. n. 002April 23, 8810, 2021).

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Data Availability Statement

Data available on request from the authors.

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