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## OPEN The effects of screen habits on attentional skills and prosocial behaviors in 6-to 36-month-old toddlers

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The rise of digital tools in the 21st century has significantly increased screen exposure among toddlers, raising concerns about its impact on their overall psychological development. Since attentional skills and prosocial behaviors play a key role in the development of toddlers' cognitive, emotional, and social functioning, the current research explores the links between screen habits of 6- to 36-month-old toddlers and their development of attentional skills and prosocial behaviors. For this purpose, we observed 148 toddlers, assessing their screen exposure via parental questionnaires and developmental outcomes using a variety of conventional experimental tasks. The main results showed that toddlers aged 6 to 18 months already exposed to screens exhibited fewer joint attention behaviors. However, sustained attention and prosocial behaviors of toddlers aged 19 to 36 months were significantly better in those who experienced interactive co-viewing during exposure. These results suggest that while extensive screen time can displace crucial developmental interactions and negatively impact early developmental skills, active parental involvement can mitigate these effects. Promoting balanced screen management and fostering strong family interactions are therefore essential to reduce potential developmental risks associated with screen exposure.

**Keywords** Toddlers, Screen habits, Co-viewing, Prosocial behaviors, Attentional skills

The beginning of the 21st century was marked by the multiplication of digital tools. As a consequence, toddlers in many countries are provided with more opportunities to be exposed from an early age<sup>1</sup>, and the amount of time they spend on them is steadily increasing<sup>2</sup>. Toddlers between 0 and 3 years are exposed on average six days a week for between thirty minutes and three hours a day (for a systematic review, see<sup>3</sup>, and this even increased following the covid-19 pandemic in more than a dozen countries studied<sup>4</sup>. Children are most often left alone in front of screens: parents or caregivers generally use media and other devices as a babysitter or as a calming tool for children<sup>5</sup>. That time spent in front of screens is time lost to other activities. This is defined in the literature as the displacement hypothesis: extended screen use would reduce the time and opportunities available for the interpersonal experiences necessary for children's socio-emotional and cognitive development<sup>6</sup>. Nevertheless, empirical evidences relating early screens exposure in toddlerhood to delays in various aspects of development are still incomplete. Most research is based on rough measures of screen time, and often fails to consider the wider context of children's screen exposure (e.g. screen type, co-viewing and content). The main results of studies show an effect on language development, but only when toddlers are left alone in front of screens. These effects are attenuated or even reversed when the caregivers actively watch the screen with the child<sup>7</sup>. In addition, several researchers highlight a positive association between screen exposure time and the development of externalizing behaviors disorders and attentional delays in toddlers from one-and-a-half to three years of age<sup>8</sup>, as well as long-term effects on cognitive and attentional development<sup>9</sup>.

More than that, a large majority of parents in Switzerland say they spend time in front of screens while their infant is present in the room<sup>10</sup>. Toddlers are therefore subjected to background screen exposure, while parents watch their shows on television or use screens in front of them. This indirect screen exposure can also have an impact on the development of attention span. Studies have shown that children's attention to play is reduced when the television is on in the background: the sounds and lights emitted by screens attract their attention, pulling them away from the activity in hand<sup>11</sup>. What's more, the interactional disconnects that occur when parents use their screen in front of their child can have an impact on their socio-emotional development.

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This phenomenon, termed technofence<sup>12</sup>, impact the attachment bond and reduce the quality and quantity of parent-child interactions (e.g.<sup>13,14</sup>). Yet these interactions are essential for toddlers to develop appropriate social, emotional, behavioral and language skills<sup>15</sup>.

The social foundations of verbal communication are established early through imitation and dyadic exchanges between parent and infant. In the first months of life, infants develop strategies to interact with their surroundings, primarily through joint attention. This involves using gestures such as pointing or gaze to engage others<sup>16,17</sup>. It serves as a pre-verbal form of communication critical for social interactions and language development<sup>18–20</sup>. Initially, infants exhibit joint attention by following an adult's gaze, with 30% of two-month-olds demonstrating this ability, increasing to nearly all infants by 11 to 14 months<sup>17</sup>. Generally, between 4 and 9 months, infants also begin to initiate spontaneous joint attention behaviors themselves, starting with gaze. They use their finger to point and draw the adult's attention to an object of interest much later<sup>21,22</sup>. These behaviors are for example observable in free play scenarios, when toddlers and their caregivers are in interaction<sup>23</sup>. These capacities are crucial for various developmental skills. Enhanced joint attention skills improve for example interactions during shared book reading, thereby promoting attention and language development<sup>24</sup>, while poor joint attention skills negatively affect language development, as less pointing and interaction reduce learning opportunities<sup>20,25</sup>.

Alongside, during the preschool years, the children's capacity for sustained attention, generally defined as the amount of time they spend focusing visually and engaged with a specific task or stimulus<sup>26</sup>, develops enormously<sup>27</sup>. As they grow, infants enhance their ability to manage attention amidst potential distractions while playing with toys, becoming more capable of planning and self-directing their attention by modulating lower-level processes<sup>28</sup>. Their attention control at a higher level becomes more important: the ability to engage in complex activities develops further and supports the maintenance of attention<sup>27</sup>. By the age of two, children are able to maintain their attention on a task for more than two to three minutes. This development is the result not only of brain maturation, but also of increased social interaction with caregivers<sup>29</sup>. Their behaviors towards children are viewed as crucial scaffolding behaviors toward the development of attentional skills: the use of positive affect during play may for example stimulate children's interest in the task and subsequently refocus their attention<sup>30,31</sup>.

Moreover, caregivers play a crucial role in toddlers' social development, as their support and social experiences facilitate the acquisition of culturally and socially appropriate behaviors<sup>32</sup>. Prosocial behavior encompasses a variety of voluntary and intentional actions aimed at benefiting others (e.g., helping, comforting, sharing<sup>33</sup>). The development of such skills begins early in life and increases with age. By less than a year old, infants prefer individuals who display helping behaviors over those who exhibit antisocial behaviors<sup>34</sup>. They also show markers of cognitive and affective empathy when confronted with their mother's simulated distress<sup>35</sup>. At around 14 months, they begin to show empathic concern and act to improve others' well-being: they can assist someone unable to complete a task or help by retrieving out-of-reach objects (e.g., picking up a pen dropped by one experimenter and give it back to him<sup>36,37</sup>). Their actions are motivated by prosocial intentions, with the sole aim of helping the person in need<sup>38</sup>. Prosocial motivation development hinges on understanding others' goals and intentions, alongside self-awareness skills and socio-emotional comprehension: children with advanced social skills show greater empathy in response to others' suffering compared to those less socially developed<sup>39</sup>. This development is partially driven by socialization<sup>40</sup>. Generally, before the age of one and a half, children adopt prosocial behaviors by imitation. Observing prosocial models positively influences children's behavior: toddlers who witness adults helping peers are more likely to mimic such behavior<sup>41,42</sup>. Caregivers also have a considerable role to play: it is through their support and the social experiences they provide that toddlers can adopt culturally and socially appropriate behaviors<sup>32</sup>.

These skills are intimately linked: eye contact, and therefore joint attention, is a prerequisite for human empathy and appropriate interactions<sup>19,43</sup>. In addition, joint attention requires skills for attention detection, social coordination and intentional understanding, skills that also are necessary for the development of prosocial behaviors<sup>21</sup>. Moreover, better sustained attention skills are associated with greater social competences<sup>44,45</sup> and all these capacities play a key role in the development of toddlers' cognitive, emotional, and social functioning<sup>22,30,46</sup>. To support the harmonious development of such skills, which are particularly sensitive during the first three years of life, toddlers need support and help of their caregivers<sup>47</sup>.

However, screens reduce learning opportunities and interactions between infants and caregivers, whether through direct use by the child or through the background exposure and the phenomenon of technofence. This study therefore aims to understand the links between screen-use habits and the development of 6- to 36-month-old toddlers' attentional skills and prosocial behaviors, as well as possible links with confounding factors such as the practice or none of interactive co-viewing during exposure (i.e. a parent interacting with their toddler during direct screen exposure time, for example by providing information about the content or pointing at the screen and explaining what's happening in the story<sup>10</sup>). For this purpose, different experimental tasks were proposed as function of age. Concerning the screen-use habits (measured by questionnaire), we would expect to find an increase in direct screen exposure time with age, whereas background screen exposure time would be observed from the earliest age and remain stable over the years. Concerning the links between toddlers' screen-use habits and the development of their attentional skills and prosocial behaviors, we hypothesized that: (1) Direct and background screen exposure time have a negative influence on the 6- to 36-month-old toddlers' development of such skills, as a consequence that toddlers with greater screen exposure time have weaker competencies; (2) Since interactive co-viewing during exposure enables dyadic interactions, toddlers who engage most or all of the time in interactive co-viewing during direct screen exposure would have a better development of their attentional skills and prosocial behaviors, regardless of their total screen time exposure.

Measures	6–18 months		19–24 months		25–36 months	
	GR0	GR1	GR0	GR1	GR0	GR1
Direct screen exposure time (min/day)	-	13 (16)	8 (9)	94 (49)	13 (13)	116 (101)
Background exposure time (min/day)	59 (17)	174 (102)	63 (15)	226 (102)	59 (24)	184 (71)
Total screen exposure time (min/day)	59 (17)	174 (102)	77 (29)	284 (125)	73 (28)	265 (120)

**Table 1.** Means and standard deviations of screen exposure time in minutes per day for subgroups of each age group.

Measures	Direct screen exposure time		Background exposure time		Total screen exposure time	
	GR0 (N=22)	GR1 (N=22)	GR0 (N=34)	GR1 (N=10)	GR0 (N=32)	GR1 (N=12)
<i>Joint attention task</i>						
Pointing	0.50 (1.406)	0.36 (0.658)	0.47 (1.187)	0.30 (0.675)	0.50 (1.218)	0.25 (0.622)
Alternating looks	7.64 (2.871)	4.77 (2.654)	5.94 (3.035)	7.10 (3.281)	5.97 (3.126)	6.83 (3.040)
Total number of signs of joint attention	8.14 (3.121)	5.14 (2.532)	6.41 (3.248)	7.40 (3.026)	6.47 (3.341)	7.08 (2.843)
<i>Cooperative task</i>						
Blocks given	1.59 (1.436)	1.23 (1.232)	1.53 (1.308)	1.00 (1.414)	1.53 (1.295)	1.08 (1.443)

**Table 2.** Means and standard deviations of joint attention and cooperative task scores depending on screen habits for each subgroup (GR0 vs. GR1) of 6- to 18-month-old toddlers.

Measures	Direct screen exposure time		Background exposure time		Total screen exposure time		Interactive co-viewing	
	GR0 (N=26)	GR1 (N=8)	GR0 (N=23)	GR1 (N=11)	GR0 (N=23)	GR1 (N=11)	GR0 (N=24)	GR1 (N=10)
<i>Sustained attention task</i>								
Comprehension score	1.52 (0.981)	2.00 (1.414)	1.65 (0.996)	1.60 (1.265)	1.71 (0.985)	1.50 (1.269)	1.69 (1.109)	1.67 (1.323)
Concentration index	4.12 (0.909)	4.63 (0.518)	4.35 (0.714)	4.00 (1.977)	4.17 (0.887)	4.36 (0.809)	4.00 (0.882)	4.40 (0.843)
<i>Pen and stacking blocks tasks</i>								
Total score	2.50 (2.214)	1.75 (2.121)	2.00 (1.977)	3.00 (2.530)	2.13 (2.138)	2.73 (2.328)	1.89 (2.470)	3.20 (1.751)

**Table 3.** Means and standard deviations of sustained attention and pen and stacking blocks tasks scores depending on screen habits for each subgroup (GR0 vs. GR1) of 19- to 24-month-old toddlers.

## Results

### Effect of screen habits on attentional and prosocial skills for each age group

The direct screen exposure time, the background screen exposure time and the total screen exposure time per day are presented for each subgroup in Table 1.

#### 6- to 18-month-old toddlers

Table 2 showed the scores obtained on the experimental tasks by each subgroup of toddlers between 6 and 18 months based on screen habits.

*Joint attention.* The results indicated that there were significant differences between the number of alternating looks and the total number of signs of joint attention depending on the direct screen exposure, respectively  $z = -2.967$ ,  $p = .003$ ,  $r = .449$  and  $z = -2.942$ ,  $p = .003$ ,  $r = .444$ . Toddlers who were not yet directly exposed to screen initiated more signs of joint attention, particularly more alternating looks. However, the results indicated that there were no significant differences between the number of pointing, the number of alternating looks and the total number of signs of joint attention depending on the background screen exposure time and the total screen exposure time.

*Cooperative task.* The results showed that more than half of toddlers between 6 and 18 months helped the experimenter at least once ( $N = 26$ , 59.1%). However, the results indicated that there were no significant differences in helping behaviors depending on the direct screen exposure, the background screen exposure time, and the total screen exposure time.

#### 19- to 24-month-old toddlers

Table 3 showed the scores obtained on the experimental tasks by each subgroup of toddlers between 19 and 24 months based on screen habits.

Measures	Direct screen exposure time		Background exposure time		Total screen exposure time		Interactive co-viewing	
	GR0 (N=52)	GR1 (N=18)	GR0 (N=49)	GR1 (N=21)	GR0 (N=47)	GR1 (N=23)	GR0 (N=26)	GR1 (N=39)
<i>Sustained attention task</i>								
Comprehension score	3.27 (1.379)	2.89 (1.711)	3.02 (1.808)	3.52 (1.504)	3.13 (1.837)	3.26 (1.514)	2.65 (1.672)	3.54 (1.790)
Concentration index	4.71 (0.536)	4.61 (0.850)	4.63 (0.698)	4.81 (0.402)	4.72 (0.540)	4.61 (0.783)	4.42 (0.809)	4.87 (0.339)
<i>Pen and stacking blocks tasks</i>								
Total score	2.42 (2.127)	2.67 (2.376)	2.31 (2.113)	2.90 (2.322)	2.28 (2.061)	2.91 (2.392)	1.92 (2.077)	2.77 (2.276)

**Table 4.** Means and standard deviations of sustained attention and pen and stacking blocks tasks scores depending on screen habits for each subgroup (GR0 vs. GR1) of 25-to 36-month-old toddlers.

Measures	6–18 months	19–24 months	25–36 months	<i>p</i>
<i>Screen habits</i>				
Direct screen exposure time (min/day)	6 (13)	28 (44)	40 (68)	<0.001
Background exposure time (min/day)	83 (69)	116 (97)	96 (72)	0.104
Total screen exposure time (min/day)	89 (75)	144 (122)	136 (116)	0.002
<i>Sustained attention task</i>				
Comprehension score	-	1.63 (1.079)	3.17 (1.728)	-
Concentration index	-	4.24 (0.855)	4.69 (0.627)	0.004
<i>Pen and stacking blocks tasks</i>				
Pen task	-	0.91 (1.264)	1.37 (1.406)	0.148
Stacking blocks tasks	-	1.41 (1.373)	1.11 (1.346)	0.297
Total score	-	2.32 (2.184)	2.49 (2.179)	0.727

**Table 5.** Evolution of screen habits and scores on different tasks as a function of age groups.

*Sustained attention.* The results indicated no significant differences between the total number of correct answers and the concentration index depending on the direct screen exposure time, the background screen exposure time, the total screen exposure time, and the practice or none of co-viewing (all  $p_s > 0.05$ ).

*Pen and stacking blocks tasks.* The results indicated no significant differences between the total score of prosocial behaviors depending on the direct screen exposure time, the background screen exposure time, the total screen exposure time, and the practice or none of co-viewing. One result approached the conventional level of significance, suggesting a possible difference in the total prosocial behavior score depending on whether toddlers engaged in interactive co-viewing. Toddlers who did not engage in interactive co-viewing during exposure showed slightly lower total prosocial behavior scores than those who did,  $U = 135.500$ ,  $p = .062$ ,  $r = .328$ .

*25- to 36-month-old toddlers.*

Table 4 showed the scores obtained on the experimental tasks by each subgroup of toddlers between 25 and 36 months based on screen habits.

*Sustained attention.* The results indicated no significant differences between the total number of correct answers and the concentration index depending on the direct screen exposure time, the background screen exposure time and the total screen exposure time. However, there was significant differences between the total number of correct answers and the concentration index depending on the practice or none of co-viewing, respectively,  $t(63) = -2.004$ ,  $p = .049$ ,  $d = 1.744$  for the total number of correct answers and  $z = 2.8$ ,  $p = .005$ ,  $r = .347$  for the concentration index. Toddlers who did not engaged in interactive co-viewing during exposure scored lower on both components than toddlers who did.

*Pen and stacking blocks tasks.* The results indicated no significant differences between the total score of prosocial behaviors depending on the direct screen exposure time, the background screen exposure time and the total screen exposure time. However, there was a significant difference between the total score of prosocial behaviors depending on the practice or none of co-viewing,  $z = 2.082$ ,  $p = .037$ ,  $r = .258$ . Toddlers who did not engage in interactive co-viewing during exposure had a lower total score of prosocial behaviors than toddlers who did.

### Effect of age on screen habits, attentional skills and prosocial behaviors

Table 5 presented the evolution of screen habits and scores on the attention and prosocial behaviors tasks, as a function of the toddlers' age.

*Screen habits.* The results indicated that there was a significant difference in direct screen exposure time across age,  $\chi^2(2, N=148)=31.246, p<.001$ . Post-hoc comparisons indicated that the direct screen exposure time of toddlers between 6 and 18 months was significantly lower than that of toddlers between 19 and 24 months,  $p=.002$ , and toddlers between 25 and 36 months,  $p<.001$ . The difference between toddlers between 19 and 24 months and toddlers between 25 and 36 months was not statistically significant but approached the conventional level of significance,  $p=.088$ . The test also indicated that there was a significant difference in total screen exposure time across age,  $\chi^2(2, N=148)=12.823, p=.002$ . Post-hoc comparisons indicated that the total screen exposure time of toddlers between 6 and 18 months was significantly lower than that of toddlers between 19 and 24 months,  $p=.006$ , and toddlers between 25 and 36 months,  $p<.001$ . However, there was no significant difference between the total screen exposure time of toddlers between 19 and 24 months and toddlers between 25 and 36 months,  $p=.940$ . Conversely, there was no significant differences between age groups in terms of background screen exposure time,  $\chi^2(2, N=148)=4.534, p=.104$ .

*Sustained attention.* The results indicated that the sustained attention capacities evolved with age: toddlers between 25 and 36 months had a significantly higher concentration index than toddlers between 19 and 24 months,  $t(102)=-2.736, p=.004$ .

*Pen and stacking blocks tasks.* The results indicated no significant differences between toddlers aged 19 to 24 months and those aged 25 to 36 months in terms of prosocial behaviors (all  $ps>.05$ ).

### Link between prosocial and attentional skills

Independently of screen-use habits, the results also highlighted a correlation between the total score of prosocial behaviors and the total number of correct answers to the sustained attention task in toddlers between 25 and 36 months,  $r=.239, p=.046$ . Toddlers with higher total score of prosocial behaviors also had better attentional skills. Detailed correlation results for each age groups are provided in Supplementary Tables S1–S3 online.

### Discussion

In the present study, we investigated whether direct and background screen exposure time was related to the development of toddlers' attentional skills and prosocial behaviors, as well as possible links with confounding factors such as the practice or none of interactive co-viewing during exposure. To assess these skills, we selected assessment tasks widely used in the literature<sup>23,37,42,48</sup>.

First, we confirmed a difference in toddlers' screen exposure time between those aged 6–18 months and the older toddlers in our sample, with longer exposure times among the latter, in line with the existing literature (e.g.<sup>49</sup>). Meanwhile, parents' use of screens in their presence appears to have remained stable over the years, at around an hour and a half per day. The interactional disconnects that result from parents' use of screens in the presence of their toddler therefore occur from an early age, whether or not the toddler is directly exposed to screens.

Then, and most importantly, the results indicated that screen habits may have a role to play in the development of toddlers' attentional skills and prosocial behaviors, in line with our two main hypotheses. More specifically, the results partially validated our first hypothesis by highlighting a link between 6-to 18-month old toddlers' direct exposure to screens and the development of their joint attention skills, while they fully validated the second by highlighting a difference in the development of attentional skills and prosocial behavior in older children, depending on whether or not they engaged in interactive co-viewing during exposure.

The results concerning toddlers between 6 and 18 months first indicated that they generally initiate joint attention by alternating looks. They are still very few in pointing at the object of interest: this capacity develops later in connection with the development of fine motor skills<sup>21,22</sup>. Nevertheless, our results revealed for the first time that toddlers between 6 and 18 months who are already and directly exposed to screen initiate fewer signs of joint attention, particularly fewer alternating looks, with the experimenter. Some results of research argue that age of first exposure to screens may be important factor affecting toddlers' development and cognition<sup>50</sup>. This could explain why infants who are exposed so early show fewer capacities. Those infants may also spend less time interacting and exploring their environment because of screens. However, as exposure times at this age are still very low, our results cannot be explained by the displacement hypothesis alone, and the consequent lack of interactions. It's probably not just whether or not infants are exposed to screen that caused this difference in joint attention skills, but family factors linked to the exposure and toddlers' environment. Parents who exposed their infant to screens at this age are never engaged in an interactive co-viewing during exposure: all of them said they used screens as babysitters, not like an activity to be carried out with their infant. Perhaps, then, these are also parents who interact less with their children, while interactions are necessary for the development of joint attention skills. Moreover, joint attention capacities are linked to the attachment bond created between caregiver and infant: at fifteen months, toddlers who have developed an anxious-avoidant attachment with their caregiver will be more inclined to enter into interaction with a third person and initiate signs of joint attention more with them than those with a secure attachment<sup>51</sup>. On the other hand, these are toddlers who initiate less signs of joint attention with their attachment figure. Since technofence can have an impact on the creation of the attachment bond<sup>14</sup>, it would therefore have been interesting to measure the number of signs of joint attention initiated towards the caregiver, and not just the experimenter. It is possible that in this situation, an effect of background screen exposure was highlighted, with highly exposed children initiating less joint attention.

Concerning the older toddlers, we found that sustained attentional skills and prosocial behaviors develop smoothly and habitually: we could observe an increase in sustained attention time during shared reading between children aged 19 to 24 months and those aged 25 to 36 months. Sustained attention skills develop rapidly at this age, and this is what the results indicated. Then, in line with existing developmental data<sup>37</sup>, toddlers between 19 and 24 months and between 25 and 36 months helped the experimenter in the vast majority of cases. Although the results do not seem to indicate a link with direct and background screen exposure time for these two age

groups, they indicated a significance difference in the development of sustained attention skills and prosocial behavior with the practice or none of co-viewing during exposure for toddlers aged 25 to 36 months. Toddlers who do not engage in interactive co-viewing have a lower total score than toddlers who do. These results also tended towards significance for prosocial behaviors of toddlers aged 19 to 24 months, although the effect was not yet as marked as in older children. It would thus seem that the practice of interactive co-viewing, and parental support more generally, is of vital importance to children's development. Indeed, it is plausible that parents who engage more in co-viewing with their toddler are also those who plan and carry out more shared activities on a daily basis. The correlation found between the sustained attention scores of toddlers between 25 and 36 months and their scores on prosocial behavior tasks supports these findings. A child who is good in one area is also good in the other: this suggests that the child's development is harmonious, and that daily parental support helps the child to develop in multiple ways, whether or not this support is based on digital tools.

Generally, the displacement hypothesis postulates that toddlers who spend the most time in front of screens (i.e. direct screen exposure) are those who have fewer opportunities to receive training in the social environment of parents and that screen exposure makes them more passive. This passive state could apply to other contexts<sup>52</sup>, thus making them less socially active and therefore less competent. In addition, screen exposure captures and holds toddlers' attention and consequently reduce the number of high-quality interactions. However, research suggests that positive effects of screen use on parent-child interactions may be observed when parents are actively engaged in interactive co-viewing and help them to understand the plot of the story, compared to passive co-viewing, in which parents do not intervene or mediate the content<sup>53,54</sup>. When parents provide relevant comments, descriptions and feedback – as is the case in our sample, when parents indicated that they were engaged in interactive co-viewing with their toddlers during screen exposure – the quality of interactions and understanding of the story are enhanced. The same goes for shared reading activity: parent-child book reading time facilitates exchanges, interactions, the development of joint attention, pointing, and even language later on<sup>55</sup>. Reading with one's child would even explain 8% of the differences observed in young children's language skills<sup>56</sup>, regardless of book format. It is indeed possible to promote such activities and support children in these different learning processes through digital applications created specifically for this purpose<sup>57</sup>. Prevention can therefore take place at multiple levels, and can be adapted to parents according to the activities they prefer to carry out with their child. The most important thing would be to guide parents in the proper use of screens and promoting various activities to be carried out daily at home towards combating screen-induced passivity in toddlers. To foster toddlers' social and attentional development, the key is also to find the right combination between balanced screen management, adequate parental support and strong family ties<sup>58</sup>.

However, there are several limitations to this study. First, data on screen-use habits were collected by questionnaire. Parental self-reports might not be the best way to collect data on toddlers' screen exposure, as parents do not accurately assess screen exposure time<sup>59</sup>, and social desirability may lead them to underestimate the total number of minutes they spent in front of screens, as well as the number of occurrences of interactional disconnects caused by screens<sup>60,61</sup>. Furthermore, all the toddlers assessed are cared for by childcare services at least once a week. Research suggests that children who attend daycare are less likely to experience developmental vulnerabilities. On the contrary, toddlers' daycare experiences have been shown to influence their developmental trajectories and play a role in their social and cognitive development, as well as in their subsequent educational success<sup>62</sup>. The potential effects of screen exposure on toddlers' social and attentional development, underpinned mainly by the displacement hypothesis and the phenomenon of technofence, could thus be counterbalanced by the social experiences and activities carried out daily at the daycare, where even adults don't use screens in the presence of toddlers. Finally, it would have been beneficial to consider the type of screens used and the nature of the programs viewed, as these factors may also play a role in the development of early childhood skills. The use of interactive digital tools, such as smartphones or tablets, can, for example, promote interactions and exchanges that are beneficial for the development of children's socio-emotional skills<sup>63</sup>, while also potentially hindering interactions and impacting the development of joint attention skills by capturing all of the toddler's attentional resources<sup>64</sup>.

Based on a precautionary principle, international guidelines recommend banning screens before age one-and-a-half<sup>65</sup>. However, interactive co-viewing emerged as a critical factor in mitigating potential negative effects of passive screen exposure. Despite the potential disruptions in interactions caused by screens, our results indicated that toddlers who engaged in co-viewing with their caregivers showed better sustained attention and higher prosocial behavior scores, highlighting the importance of active parental involvement during screen exposure and suggesting that with proper guidance, screens could be integrated into toddlers' lives, while minimizing any potential negative effects associated with them. In conclusion, while screen exposure poses risks to toddlers' development, these can be mitigated through interactive co-viewing practices. Educating parents on effective screen use and promoting interactive activities are therefore essential.

## Methods

### Participants

This study included observations of 148 infants: forty-four aged 6 to 18 months ( $M = 12$  months,  $SD = 3$ ), thirty-four aged 19 to 24 months ( $M = 21$  months,  $SD = 2.5$ ), and seventy aged 25 to 36 months ( $M = 31$  months,  $SD = 4$ ). Families were recruited through child daycare facilities, with no exclusion criteria for toddlers. However, parents needed to be French speakers to complete the questionnaire. The average socio-economic status of the families was classified at entrance to the Swiss upper-middle class, based on an index derived from the age, education level, and professional category of both parents ( $M = 70.97$ ,  $SD = 12.262$ <sup>66</sup>).

## Procedure

This study was a part of a broader project exploring the links between screen habits and various aspects of child development. It was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Faculty of Psychology and Educational Sciences at the University of Geneva (PSE.20201102.02/ March 25, 2021). All sessions were filmed and conducted individually with each toddler and their parent or accompanying daycare staff. The principal investigator provided a detailed explanation of the procedures to all parents, and written informed consent was obtained from parents and/or legal guardian(s) prior to the toddlers' participation in the study. Parents also completed the online questionnaire before the assessment sessions. During the assessments, toddlers were asked to engage in various tasks, including those measuring attention and prosocial behaviors.

## Study measures

### *Screen habits*

The screen habits of toddlers and their parents were assessed using an online questionnaire (Qualtrics, Provo, UT) completed by parents. This questionnaire was developed as part of a larger research program conducted at the University of Geneva on screen-use habits among toddlers under three years of age and their families. Data regarding toddlers' screen habits were previously collected on a large scale and are reported in an earlier publication<sup>10</sup>, where further details about the questionnaire can be found. For the present study, the same questionnaire was used. Parents were asked, "How many times on average does your child use and/or look at this (these) screen(s) during a typical week (Monday to Friday)?" followed by "What is the average duration of each exposure?". The responses obtained were used to create four variables: (1) Parents reported the number of minutes per day their toddler spent in front of screens during an average weekday and on weekends, giving the direct screen exposure time in minutes per day over a full week; (2) Parents indicated the number of minutes per day screens were used by themselves or others in the presence of the toddler, giving the background screen exposure time in minutes per day; (3) The total screen exposure time in minutes per day was then calculated by summing the direct screen exposure time and the background screen exposure time; (4) Parents noted whether they engaged or not in interactive co-viewing with their toddler during screen exposure, specifying what this means to them (e.g. helping toddlers to understand what they are seeing or simply sitting passively with their toddler?), resulting in the variable referred to as "interactive co-viewing".

### *Attentional and prosocial experimental tasks*

Different experimental tasks assessing attentional and prosocial abilities were chosen to be appropriate to each age group and the laboratory assessment context.

#### *6-to 18-month-old toddlers*

**Joint attention.** We used a bouncing stress ball and a small mechanical robot, similar to the objects proposed in Object Spectacle Tasks of the ESCS (Early Social Communication Scale<sup>23,48</sup>). The experimenter sat opposite the child, bounced the ball six times in his hand, and repeated this action five times. He then activated the small mechanical robot, which moved forward on the table, five times. Different variables were measured from the videotape when the ball was in the tester's hand or when the mechanical robot was active on the table. We first calculated the number of alternating looks the infant made between the objects and the experimenter's eyes, as well as the number of pointing the infant realized with a clear articulation of the index finger. We then added these two scores to obtain a total number of signs of joint attention.

**Cooperative task.** This task was used to assess the imitation of helping behavior. It consisted of two parts<sup>42</sup>: the infants first observed an adult model helping the experimenter reach three blocks that were out of reach to build his tower (1) before having the opportunity to help him by giving him the three blocks he needed (2). Infants' helping behaviors were then analyzed. They obtained 1 point for each of the three blocks they gave to the experimenter. Importantly, all infants were able to grasp and manipulate the blocks. Therefore, when helping behavior was not observed, this was not due to an inability to perform the required motor actions, but rather reflected the absence of a cooperative response.

#### *19-to 36-month-old toddlers*

**Sustained attention.** Sustained attention skills were measured during a shared reading activity: the experimenter read an age-appropriate book with the child. The books used differed according to age group, but both were highly illustrated and contained text, so the experimenter's speech was standardized between infants. At the end of the reading, the experimenter asked the child various comprehension questions. Five questions were asked of children aged 19 to 24 months directly in the book, and seven were asked of children aged 25 to 36 months, on separate sheets of paper. Children were asked to point out the correct answer from three possible images. A concentration index and a comprehension score were measured. The concentration score was based on Wang's five-degree scale<sup>67</sup> ranging from 1 (when the child was not focused on the book at all) to 5 (when the child was constantly focused on the book). It referred to the proportion of time the child spent looking at and concentrating on the book and was the main measure of sustained attention. The comprehension score reflected the number of correct answers given to the comprehension questions at the end of the reading.

**Pen and stacking blocks tasks.** Two tasks developed by Warneken and Tomasello (2006) and widely used in the scientific literature were proposed to assess prosocial behaviors: the pen and the stacking blocks tasks<sup>37</sup>. During the pen task, the experimenter accidentally dropped his pen on the floor next to the toddler while drawing with him and unsuccessfully reached for it. After that, there were three phases: the experimenter focused on his pen during 10 s, then alternated gaze between his pen and child during 10 s, and finally verbalized his problem (e.g., "My pen!") while continuing to alternate gaze the last 10 s. During the stacking blocks task, the experimenter sat

opposite the child and began by carefully stacking a A5 size blocks on top of each other. Then a block slips from the stack as he attempted to place it on the top, three times in a row. For each task, toddlers obtained a score between 0 and 3 according to the behaviors they had adopted. For the pen task, toddlers obtained 3 points if they pick up the pen and gave it to the experimenter within the first 10 s, 2 points if they did it during the second phase, and 1 point if they did it during the last phase. For the stacking blocks task, 1 point was given for each block put back in place. We then added these two scores to obtain the total score of prosocial behaviors.

### Data analysis

Data analyses were conducted post-collection. To verify inter-observer reliability, two independently trained psychologists evaluated each variable separately. Discrepancies were resolved through joint video review and recoding by both evaluators.

To establish the independent variables related to screen habits, toddlers in each age group were categorized into two groups. For direct screen exposure time, we adhered to the common international guidelines (i.e., no screen time before 18 months and less than one hour per day thereafter<sup>65</sup>), consistent with several studies (e.g.<sup>68,69</sup>...). Toddlers aged 6 to 18 months were divided according to whether they had already been exposed to screens or not: those without exposure were placed in group 0 (GR0), and those with exposure in group 1 (GR1). Given that most toddlers aged 19–24 months and 25–36 months adhered to the guidelines, we categorized these age groups based on their actual screen time, dividing them according to the daily average screen time. Toddlers exceeding the average were placed in group 1 (GR1), while those at or below the average were placed in group 0 (GR0). For background screen exposure time and total screen exposure time, no specific guidelines were available. Hence, toddlers were divided into two groups based on the average daily screen time. Toddlers above the average were placed in group 1 (GR1), and those at or below the average in group 0 (GR0). Additionally, parents reported whether they engaged or not in interactive co-viewing with their toddlers during screen exposure. Toddlers who experienced interactive co-viewing were assigned to group 1 (GR1), and those who did not were placed in group 0 (GR0), except for toddlers aged 6 to 18 months, who did not engage in interactive co-viewing at all.

We conducted data analysis using IBM SPSS Statistics, Version 29.0.2.0 (IBM Corp, 2023). We first ran Kolmogorov–Smirnov to assess the normality of the data where relevant (e.g. for screen times and comprehension score). Based on these results, we ran Independent-samples t-tests for normally distributed variables and Mann–Whitney tests for non-normally distributed variables (i.e. when the data failed to meet assumptions of parametric analysis). For instance, the comprehension score and the concentration index, both of which assess sustained attentional abilities, were tested for normality, and appropriate statistical tests were applied. For these various analyses, we used screen habits (direct screen exposure time, background exposure time, total screen exposure time, and interactive co-viewing) as independent variables and the scores obtained on various tasks assessing attentional abilities and prosocial behaviors as dependent variables. We also ran Pearson correlations between the different scores obtained in attention tasks and the prosocial behaviors scores of each group of age. Finally, to assess the evolution of screen habits between age groups, we ran Kruskal–Wallis test and post-hoc comparisons when results were significant using Dunn’s method with a Bonferroni correction. We also ran Independent-samples t-tests to assess changes in experimental task scores (when comparable) between age groups. A significance level of 0.05 was used for all statistical tests. Additionally, effects with *p*-values between 0.05 and 0.10 were reported and interpreted with caution as suggestive rather than conclusive.

### Informed consent

Written informed consent was obtained from the parents for their own participation and for their toddler’s participation in the study.

### Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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## Author contributions

E.G. wrote the main manuscript text. All authors have reviewed the manuscript.

## Declarations

## Competing interests

The authors declare no competing interests.

## Additional information

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