Young Children's Screen Time During the First COVID-19 Lockdown in 12 Countries

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Abstract

This study examined children's screen time during the first COVID-19 lockdown in a large cohort (n=2209) of 8-to-36-month-olds sampled from 15 labs across 12 countries. The sample was largely balanced by sex, though most participants were majority White. Caregivers reported that young infants and toddlers with no online schooling requirements were exposed to more screen time during lockdown than before lockdown. While this was exacerbated for countries with longer lockdowns, there was no evidence that the increase in screen time during lockdown was associated with children's demographics, e.g., age, SES. However, screen time *during* lockdown was negatively associated with child age and SES and positively associated with caregiver screen time and attitudes towards children's screen time.

Keywords: screen time, COVID-19, multi-country

In March 2020, the COVID-19 outbreak led to lockdowns and social distancing measures around the globe: Social interactions were restricted and many parents had to work from home while taking care of their children, because nurseries, kindergartens, and schools were (partially) closed. The move to online schooling led school-aged children to spend many hours a day in front of screens, interacting with their teachers and classmates. Unsurprisingly then, older children (3- to 17-year-olds) in many countries (Australia, China, France, Germany, Italy, Netherlands, South Korea, Spain, UK, USA; see Table 1) spent extended periods engaged with digital media during lockdown. What about the youngest members of our society, young children from a few months to a few years old, who did not attend online schooling? What was their experience with screen time during this lockdown period? What were the factors that shaped their screen time exposure during lockdown? Were they exposed to increased periods of screen time during lockdown as their caregivers battled to keep them occupied while working from home, and was there an association between potential increases in screen time during lockdown and children's language development? The current study addresses these questions by examining screen time during lockdown in children aged 8 to 36 months using data from 15 labs across 12 countries (Canada, France, Germany, Israel, Norway, Poland, Russia, Saudi Arabia, Switzerland, Turkey, UK, USA).

Screen Time in Early Childhood

Children start using digital media devices early in life (Bedford et al., 2016; Ribner & McHarg, 2021; Rideout & Robb, 2020), with a study in the US suggesting a 32% increase in children's screen time in the last two decades (Goode et al., 2020). Children's screen time also increases with age (Alroqi et al., in press; Bedford et al., 2016; Nevski & Siibak, 2016; Paudel et al., 2017; Rideout & Robb, 2020), with two-year-olds in the US having less than an hour a day of screen time and two- to four-year-olds having on average 2.5 hours screen time a day (Rideout & Robb, 2020). During screen time, there appears to be a focus on entertainment-based content or nursery rhymes and songs, relative to informative content (Alroqi et al., in press; Rideout & Robb, 2020; UK Office of Communications, 2019). Globally, as of May 2021, the most viewed YouTube video of all time was a children's song, and five of the top ten most-viewed YouTube videos were directed at children (YouTube, 2021).

There also appear to be considerable cross-country differences in screen time for children (Chaudron et al., 2018; De Decker et al., 2012; Santos et al., 2017). Four to six-year-olds from medium-high SES families in Germany and Spain were reported to have 20-30 minutes of TV time a day, whereas the estimate was between 0.5-1.5 hours in Greece, and 1-4 hours in Belgium, Poland, and Bulgaria (De Decker et al., 2012). However, most studies have focused on children from English-speaking countries (Duch et al., 2013; Hoyos Cillero & Jago, 2010). For example, while Duch and colleagues (2013) identified 29 studies concerning screen time in children aged ≤ three years, 25 of the studies were conducted in the US, with only four from Europe and East Asia. Thus, there is a gap in the literature with regards to a more global perspective on young children's screen time. Moreover, available survey estimates tend to focus on older children: For example, EU Kids Online or the UK's Office of Communications, which publishes annual survey results of children's screen time, does not provide data for children under three.

Screen time is strongly embedded in the familial context, with older siblings often showing their younger siblings how to use media devices, helping them choose content, and co-using digital devices or co-viewing (Domoff et al., 2019; Nevski & Siibak 2016; but see Duch et al., 2013 and Hinkley et al., 2010 for null results). This sibling influence on screen time entails that infants and toddlers with older siblings are often exposed to content that is targeted at older children (Bentley et al., 2016; Zimmerman et al., 2007). Furthermore, there are differences in co-viewing and co-using patterns across early development, with some studies finding that the rate of parent-child co-use of mobile media is highest in children younger than two years and decreases dramatically as the child grows older (Paudel et al., 2017; Rideout & Robb, 2020).

Exposure to screen time may be particularly exacerbated in children from lower socio-economic status families (SES, De Decker et al., 2012; De Lepeleere et al., 2018; Hoyos Cillero & Jago, 2010; Hutton et al., 2020; Kabali et al., 2015; Linebarger et al., 2013; Rideout & Robb, 2020; Supanitayanon et al., 2020). Reports suggest that 97% of children aged six months to four years from low-income backgrounds in the US used mobile devices and that most children started using them before their first birthday (Kabali et al., 2015). Caregiver education is also strongly associated with screen time given findings that, among 0-8-year-olds, the average daily screen time varies from 3 hours and 12 minutes for children whose caregivers have a high school diploma (or less) to 2 hours and 24 minutes for children whose caregivers have some college experience, and 1 hour and 38 minutes for children whose caregivers have a college degree (Rideout & Robb, 2020). In keeping with this, a recent large-scale multinational study, on which the present study draws, also found a negative association between maternal education and young children's screen time during the pandemic (Kartushina et al., 2021).

Caregiver behaviours and attitudes also play an important role in young children's screen time. Caregivers of children under three years of age reported allowing their children more time with smart devices, the more time they reported using touch screens themselves (Nevski & Siibak, 2016), while also noting that by allowing their children to use media devices, they provided them with opportunities to acquire new knowledge and/or provided them with entertainment. Caregivers with stronger beliefs about the educational benefits of screen time were more likely to co-use mobile media with their child than to have the child use mobile media alone (Levine et al., 2019). One- to four-year-olds were also more likely to have access to their caregiver's smartphone if caregivers believed that it was important for their child to familiarize themselves with technology (Roy & Paradis, 2015).

Taken together, the studies reviewed above suggest that children have access to screen time from early in the first year of life and screen time is linked to socio-demographic factors such as child age, socioeconomic status of the family, the number of siblings a child has as well as environmental factors such as caregiver's screen time and attitudes towards screen time, although these effects appear to vary globally.

Children's Screen Time During COVID-19 Lockdown

In addition to the socio-demographic factors discussed above, screen time also appears to be modulated by disruptive external influences. For example, studies report more screen time among hospitalized children (Guttentag et al., 1983; Simon et al., 2010). More recently, in addition to pre-existing differences in children's physical activity and screen time across countries (Whiting et al., 2020), the COVID-19 pandemic and the associated lockdown measures has triggered an increase in screen time in many regions. Table 1 presents the key findings of studies examining lockdown-related increases in screen time among older children across several countries. Taken together, these studies suggest a widespread, immediate, and potentially adverse impact on the rates of children's screen time as a consequence of the COVID-19 lockdown measures in older children between 3 to 18 years of age. Nevertheless, no single study has examined the effects of lockdown and associated measures, including lockdown severity and duration on young infants' and toddlers' screen time across countries.

Table 1. Previous findings on lockdown-related increases to children's screen time

Country	Age	Screen time effect

Canada	5- to 11-years	95% of children not meeting guidelines for physical activity due to sedentary behaviour including screen time (Moore et al., 2020)
China	6- to 17-years	30 hours more screen time per week (Xiang et al., 2020)
France	6- to 10-years	62% of children had increased screen time (Chambonniere et al., 2021)
Germany	4- to 17-years	One hour more screen time per day (Schmidt et al., 2020)
Italy	6- to 18-years	Almost 5 hours more screen time per day in children with obesity (Pietrobelli et al., 2020)
Netherlands	6- to 14-years	Self-reported screen time increased by 59-62 minutes per day (ten Velde et al., 2021)
South Korea	age not reported	81% of children had increased screen time (Guan et al., 2020)
Spain	8- to 16-years	2 hours more screen time per day (Medrano et al. 2020)
USA	< 18 years	'Dramatic' increase in screen time (Hartshorne et al., 2020)
Multi-country	3- to 7-years	50 minutes more screen time per day (Ribner et al., 2021)

Lockdown Severity Across Countries

The period and implementation of lockdowns and social distancing measures introduced to contain the pandemic differed widely across countries, resulting in various degrees of lockdown severity. To account for lockdown severity, the Oxford COVID-19 Government Response Tracker (OxCGRT) project suggested a Stringency Index, based on the following factors: school and daycare closures, workplace closures, cancellation of public events, social contact restrictions, public transport closures, and movement restrictions (Hale et al., 2021). The eleven countries participating in this study imposed various degrees of lockdowns for different periods of time (see Table 3). Most countries started implementing lockdown measures in March 2020. The two countries that implemented the strictest measures according to the COVID-19 Government Stringency Index were Saudi Arabia and Israel. Although some countries allowed outdoor activities for children whilst maintaining social distancing practices (e.g., Norway and the Netherlands), others did not allow children under the age of 15 to leave the house, even after lockdown measures were eased later in 2020 (e.g., Turkey and Saudi Arabia). Against the background of studies suggesting disruptive environmental influences on children's screen time discussed above, differences in lockdown measures are likely to influence children's screen time, for example because the activities possible are more or less limited; a hypothesis which has yet to be examined empirically.

Screen Time and Language Development

Health agencies suggest that excessive screen time in the early years can be detrimental to early development (e.g., American Academy of Pediatrics [AAP] Council on Communications and Media, 2016, Australian Department of Health, 2019; Canadian Paediatric Society, 2017; German Federal Ministry of Health, 2016; Public Health England, 2013; World Health Organization, 2019). However, such reports stress that there is limited work examining the impact of screen time in young children and also highlight children's learning from digital media when caregiver support and scaffolding is provided.

The results of the few studies examining the impact of frequency and duration of screen time on children's development are mixed. On the one hand, population-based studies suggested a negative association between excessive screen time in early childhood and children's language development (Zimmerman et al, 2007), especially with regards to children's expressive (but not receptive) vocabulary (Dynia et al., 2021; see Kartushina et al., 2021 for similar results), as well as a negative association between screen time and children's receptive vocabulary and math skills, classroom engagement, and physical prowess at kindergarten (Pagani et al., 2013). On the other hand, a recent meta-analysis found that while increased screen time was associated with lower language skills, quality screen time (educational programs) and caregiver scaffolding during screen time was associated with stronger language skills in children under twelve years of age (Madigan et al., 2019). Thus, there is a need for further examination of the influence of screen time on children's language development during lockdown, especially given that children may have had increased screen time during lockdown (relative to before).

The Current Study

The current study addresses at least three limitations of previous research on young children's screen time. First, the literature currently lacks a systematic investigation of the factors associated with screen time in children under the age of three. Second, to our knowledge, there is no study of young children's screen time during lockdown, especially with regards to potential increases in screen time during lockdown relative to pre-lockdown. Third, the literature lacks a global perspective on young children's screen time. Thus, more diverse data collected through similar sampling methods is necessary to begin to understand cross-national differences in young children's screen time. Such comparative research will shed new light on the factors that influence screen time both globally and nationally, and will allow informed recommendations for young children's screen time. We address this gap by examining screen time during lockdown in an international sample of 8-to-36-month-olds.

In particular, this study has the following aims: To examine *(i)* the factors associated with young children's screen time during the first COVID-19 lockdown, *(ii)* whether there was an increase in young children's screen time during lockdown relative to before the first COVID-19 lockdown and *(iii)* the association between potential increases in screen time during lockdown and vocabulary development.

We predicted (see preregistration: https://osf.io/4h7sw/) that caregiver's screen time, caregiver's beliefs about the positive impact of screen time, maternal education level (as a proxy of SES), children's age, and the severity of the lockdown in the country will be positively associated with children's screen time. We also predicted an increase in children's screen time during lockdown, compared to before lockdown. Finally, in keeping with the influence of screen time on vocabulary development during lockdown in the original sample (i.e., Kartushina et al., 2021), we predicted that the increase in children's screen time during lockdown will be negatively associated with vocabulary gains during lockdown.

Methods

This study's predictions and analyses were pre-registered on the Open Science Framework (https://osf.io/4h7sw/) following data collection and prior to data preprocessing, visualisation and analysis. All materials, anonymized data, and analysis codes are available on the project's OSF. Deviations from the preregistration and exploratory analyses are highlighted below.

Participants

Families with infants and children aged between 8 and 36 months were recruited between March and September 2020 by 15 labs across 12 countries (Canada, France, Germany, Israel, Norway, Poland, Russia, Saudi Arabia, Switzerland, Turkey, UK, USA). Participants were recruited through online advertisements on social media and contacting caregivers registered to babylab databases. In total, data from 2209 children (and their caregivers) were entered into the models reported in this manuscript, 1292 of which were collected in the context of a larger COVID-lockdown study, henceforth referred to as the *COVID-language dataset* (Kartushina et al., 2021, see data exclusion details below).

In a subset of countries, henceforth referred to as the *COVID-screen dataset* (Germany, Israel, Switzerland, UK), additional data was collected explicitly aimed at examining children's screen time during lockdown (n = 1323, n after exclusions=992, see details below; gender information not available for this sample). Not all of the participants who were in the COVID-screen dataset were included in COVID-language dataset (and vice versa) due to these participants not providing data for mandatory questions in that study.

Some of the analyses reported here focus solely on the COVID-screen dataset (n=1323). Of these, 331 participants were excluded from the analysis for the following reasons: (a) older or younger than the specified age limit in the study (i.e., younger than 8 months or older than 36 months; *n* = 261), (b) participant information not available or conflicting participant information across datasets (*n* = 66) or (c) participants completed the study after the end of data collection (*n* = 4), leaving a total of 992 participants whose data could be entered into the different models. Across all models, we excluded participants who did not provide data for all variables included. The number and mean age of participants (in months) whose data were entered into each model are provided in Table 2.

Separate analyses examine the participants analysed in the COVID-language dataset (Kartushina et al., 2021, *n* = 1742, 888 girls), following exclusion of 450 of the original 1742 participants due to conflicts in the data provided (date at which daycares shut down for lockdown later than date of filling in the last questionnaire, *n* = 67), providing responses that deviated from the monotonous scale adopted for the current study (*n* = 353) and not providing responses for all variables entered into the model (*n* = 29). Finally, we report analyses including those participants from the COVID-language dataset (Kartushina et al., 2021) for whom we were able to obtain data on both their vocabulary development during lockdown as well as additional data on their screen time during lockdown from the COVID-screen dataset (*n* = 176, 117 of which provided data for the receptive analyses and 156 of which provided data for the expressive vocabulary analyses due to some participants providing data on both children's receptive and expressive vocabulary size).

Table 2. Number (and age in months) of participants whose data were entered into the models reported below. Numbers in brackets indicate the data for models including SES as a predictor.

Lab	*n*	Mean age at T2 in months
Model 1	1292	22.00
Model 2	951 (622)	22.22 (21.68)
Model 3	953 (622)	22.21 (21.68)
Model 4a	117	16.44
Model 4b	156	17.92

Procedure

As part of a larger global COVID-lockdown study (Kartushina et al., 2021), participants were asked to complete an online questionnaire at the beginning of the first lockdown in March 2020 (T1) and at the end or easing of the lockdown (T2) in their respective countries (between May and September 2020). Some of the participants were only presented with questionnaires at T2 (n = 615) and were asked to complete a compiled version of the T1 and T2 questionnaires that included all relevant questions for the current study at this time. T1 and T2 questionnaires also included other variables which are not investigated in this study. The entire study was conducted online. This research was carried out in accordance with the provisions of the World Medical Association Declaration of Helsinki. Each lab followed the ethical guidelines and ethics-review-board protocols of their own institution. Central data analyses exclusively used depersonalized data.

Materials

Time 1 Questionnaire

The T1 questionnaire included questions relating to children's socio-demographic characteristics (i.e. child age, exposure to [different] languages in daily life, number of siblings, caregivers' native language, caregiver education) and the child's vocabulary development at T1 (see Kartushina et al., 2021 for further details). Based on research highlighting the influential role of maternal education on children's later achievement (Kean, 2005; Kean, Tighe & Waters, 2021), we used maternal education as a proxy for socioeconomic status (SES; see Figure B1 in the Appendix for distribution of maternal education across the two datasets), measured on a scale from 1 to 6 as follows: 1 (primary school), 2 (high school), 3 (college/University), 4 (Bachelor degree), 5 (Master degree), 6 (Doctoral degree).

Vocabulary Measure. Children's receptive and expressive vocabularies were measured using age-appropriate Communicative Development Inventories (CDIs, Fenson et al. 2007) and their adaptations for the relevant language (or regional variant) of the child. Caregivers were asked to indicate whether their child understands (receptive vocabulary) and/or says (expressive vocabulary) each word in the inventory. Kartushina et al. (2021) transformed the number of words on CDIs to daily percentiles for each language using data from wordbank.stanford.edu (Frank et al., 2017) or from norming data collected by authors of that study for this explicit purpose when available. These percentile scores, calculated as described in Kartushina et al. (2021), constituted our vocabulary measure at T1 in the current study.

Time 2 Questionnaire

The T2 questionnaire included a range of questions examining children's screen time, vocabulary size at T2 (percentile score similar to T1), caregivers' screen time and caregivers' attitude towards children's screen time, described in more detail below. Some labs included other questions not included here.

Children's Screen Time: With some variation between labs, questions targeted the quantity, quality and context of children's screen time. The current study focused on the quantity of children's screen time due to considerable data loss with regards to the other descriptives. All labs asked caregivers to rate the amount of time their child spent in watching baby cartoons and shows on any device (e.g., TV, DVD, smartphone) and playing digital baby games. Some questions also separately targeted the quantity of screen time prior to and during lockdown with differences between labs in whether the questions on screen time prior to lockdown were asked at T1 or at T2. Given differences in the specific scales used across different labs, we harmonised the data to a seven-point scale (ranging from "My child never uses these devices" to "More than 4 hours per day") that collapsed across lab-specific scales or time-estimates (see Figure 1 for distribution of screen time across the participating countries).

Caregiver Screen Time. Caregivers were also asked to report their own screen use on a 10-point scale ranging from "I do not use this type of device" to "More than 6 hours per day". Some labs asked about caregivers' general use of screens whilst other labs asked about the use of specific devices separately, for example, phones, laptops and tablets, as well as whether this was in the presence of their child or not, and whether their media use was work related or not. This was harmonised to generate a single value of caregiver screen time on the same seven-point scale as children's screen time (see Figure B2 in the Appendix for visualisation of variation in caregiver screen time across the two datasets).

Caregiver Attitude to Children's Screen Time. Caregivers were asked to select any perceived positive or negative impacts of their child's screen use from a list of five positive and six negative possibilities (see Appendix A for options presented to parents and visualisation of caregivers' perception of children's screen time). For example, a potential positive impact of media use may be "this allows my child to have contact with family/friends" while a potential negative impact may be "screens lead to sibling fights".

Vocabulary Measure. As at T1, we measured children's receptive and expressive vocabularies using age-appropriate CDIs. Percentile scores based on caregiver responses on the CDIs calculated as described in Kartushina et al. (2021) constituted our vocabulary measure at T2 in the current study.

Country-Specific Lockdown Characteristics

Lockdown Severity. Due to variation in COVID-19 transmission rates and government response, the lockdown restrictions and dates varied between countries. Subsequently, the dates for T1 and T2 data collection also varied across countries. Adapting the Oxford COVID-19 lockdown Stringency Index (Hale et al., 2021), we calculated a simple additive lockdown severity index for each country on a three-point scale with one point awarded for each of the following: (1) playground closures, (2) social contact restrictions and (3) restrictions on going outside (see Table 3). We also collected data on whether daycares were shut and whether leisure and eating facilities were closed down but this data was uniform across the countries included here and were excluded from the three-point scale.

Lockdown Duration. We also calculated the duration of lockdown until the T2 questionnaire was completed in each country or region. Where available, this was based on the number of days between the date on which the T2 questionnaire was filled (the end of lockdown for that family or the end of data collection if lockdown was not yet complete) and the date on which nurseries, preschools and daycares shut in that region or country. This ranged from 35 to 151 days with a mean of 77 days; see Figure B3 (Appendix).

Table 3. Lockdown characteristics for participants (and number of participants) from the different countries contributing to the COVID-language dataset. Lockdown duration in brackets indicate the duration of lockdown for participants from the COVID-screen dataset. Participant numbers in brackets refer to participants in the COVID-screen dataset.

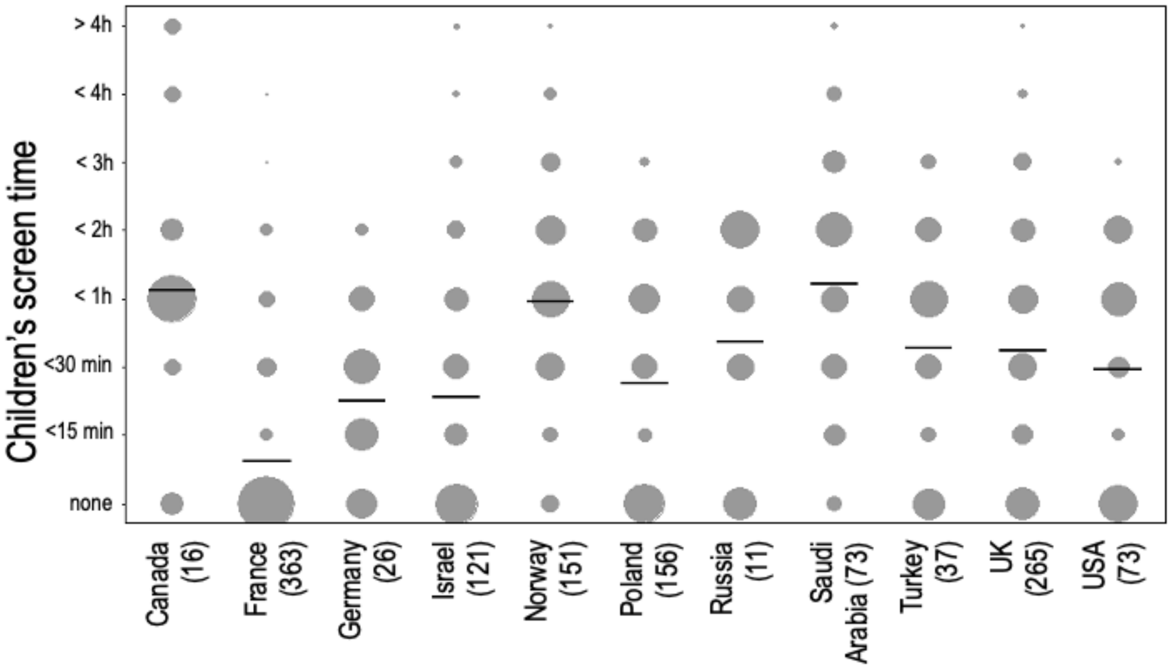
Lab	Country	n	Lockdown severity	Lockdown start date	Mean lockdown duration in days
ldl	Canada	17	1	16.03.2020	89
paris_team	France	467	3	16.03.2020	70
goe	Germany	186 (181)	2	13.03.2020	74 (124)
Technion	Israel	173 (168)	3	15.03.2020	50 (60)
babyling	Norway	173	2	12.03.2020	39
multilada	Poland	223	1	11.03.2020	71
msu	Russia	17	3	30.03.2020	96
kau-cll	Saudi Arabia	86	3	08.03.2020	103
hetsl	Switzerland	244 (244)	0	13.03.2020	89 (46)
mltlab	Turkey	40	3	16.03.2020	77
Brookes	UK	403 (399)	3	23.03.2020	87 (81)
clcu	UK	40	3	23.03.2020	86
rhul_baby_lab	UK	25	3	23.03.2020	70
cogdevlabbyu	USA	39	1	17.03.2020	45
ilpll	USA	49	1	02.04.2020	55

Preprocessing

Following import of the data from the different labs, we identified subtle differences in the scales used by the different labs. We therefore converted the scales provided by the labs to hours and minutes and then reconverted the data to a harmonised scale across labs. This was done by taking the midpoint of the time-range for each value on the scale. Also, as specified in the preregistration, since the response variable was measured on a non-monotonous 0 to 9 scale (varying from number of times per week the child has access to screen time to how many minutes per day the child has access to screen time), we excluded the values (1 and 2) that were on a different scale (number of times per week) relative to the other responses (number of times per day). For labs which collected data on screen time across a range of devices or across a variety of digital content (age-appropriate, age-inappropriate), we summed the midpoint time estimates across different devices and/or content to calculate total screen time for each participant. The final harmonised scale across countries entered into the models was the following seven-point scale: 0 (not at all), 1 (0-30 minutes a day), 2 (30-60 minutes a day), 3 (1-2 hours a day), 4 (2-3 hours a day), 5 (3-4 hours a day) and 6 (more than 4 hours a day). Figure 1 visualizes these data separately for participants from the different countries contributing to the COVID-language dataset and the COVID-screen dataset. With regards to caregiver screen time, we also excluded the values (1 and 2) that were on a different scale (per week) and only retained responses that indicated how much screen time caregivers had per day (see Figure B2 Appendix). Finally, with regards to caregivers' attitude to children's screen time, caregivers were asked to indicate which of six potentially positive and five potentially negative side-effects of children's screen time use they perceived: For example, whether screen time led to them having more time for themselves, or to siblings fighting amongst each other. We first examined whether caregivers' responses to the positive side-effects were correlated with caregivers' responses to the negative side-effects of screen time. Due to the significant correlation between these two variables, $r = .167$, $p < .001$, we collapsed the two measures as proposed in the preregistration. In particular, we calculated the percentage of positive side-effects caregivers indicated they agreed with as well as the percentage of negative side-effects caregivers indicated their agreement to and then computed the difference between these two as an index of caregiver's overall view of children's screen time. Thus, if this measure (henceforth, *caregiver affect*) were positive, it indicates that caregivers indicated they agreed with a greater proportion of the positive side-effects of screen time and vice versa if this measure were negative.

All predictor variables entered into the model were scaled (using the default scale function in R) by calculating the mean and standard deviation of all the values and then scaling each value by subtracting the mean from each value and dividing it by the standard deviation.

(A)



(B)

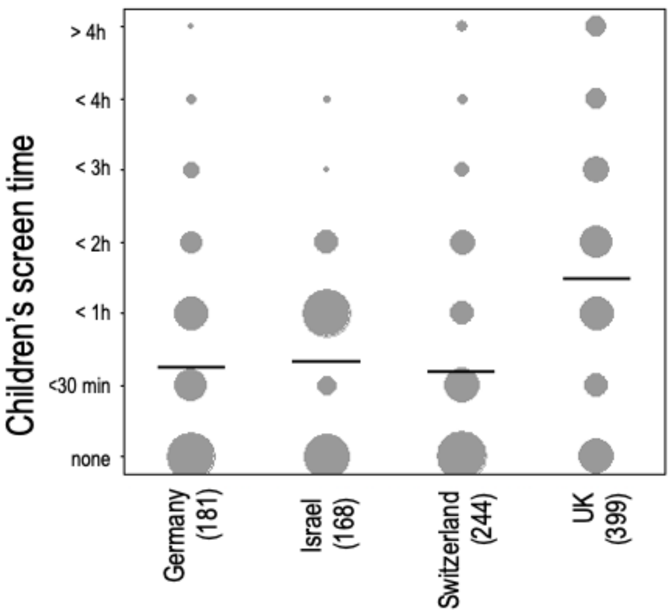


Figure 1. Caregiver reports of children's screen time (at T2) from the (A) COVID-language dataset (n=1292) and the (B) COVID-screen dataset (n = 992; before exclusion for different models)

Results

Factors Associated With Young Children's Screen Time During Lockdown

First, we examined young children's screen time during lockdown using the COVID-language dataset (Kartushina et al., 2021, https://osf.io/ty9mn/). Fixed effects entered into the model were *lockdown.severity* (on a scale of 0 to 3) and *lockdown.duration* (calculated as the number of days since the shutdown of daycares in the city where participants were located and the date the questionnaire was filled in). We also included as fixed effects the number of *siblings*, *age* of the child (in days), and *SES* (as indexed by maternal education) as well as the amount of *caregiver screen time*. We fitted an ordinal model using the *ordinal* package in RStudio (Version 1.1.463, see references for list of package citations). All theoretically identifiable random slopes on the random intercept of Country were included in the model (see **Model 1** specification and additional model parameters in Appendix C). We initially tried to include parameters for the correlations among random intercepts and slopes, but removed the correlations due to issues with model convergence. All models were fitted on complete datasets. The model reported here was compared to a null model excluding all predictors except *SES* as preregistered.

The full-null model comparison was significant, $\chi 2 = 41.51$, $df = 6$, $p < .001$, suggesting that at least one (or a combination of one or more) predictors entered into the model improved model fit. Table 4 shows the resulting parameter estimates with the p-values corresponding to drop1 analyses examining the individual contribution of each of the predictors entered into the model. Note that this model does not include the interaction between *lockdown.severity* and *lockdown.duration* (which was included in the original model) due to this interaction not being significant, *χ2* = 2.83, *df* = 1, *p* = .093 (see Model 1, Appendix C). We, therefore, report here the results of a reduced model excluding this interaction to examine potential main effects of *lockdown.severity* and *lockdown.duration*.

The model summary presented in Table 4 suggests a positive association between *caregiver screen time* and *children's screen time*, with caregivers who reported having more screen time themselves also reporting their children having more screen time. There was also a positive association between *age* of the child and screen time, with older children having more screen time than younger children (see Figure 2). Finally, there was a negative association between *SES* and screen time, with caregivers from lower SES families reporting their children having more screen time (see Figure 2). We found no evidence for associations between screen time and *lockdown.severity*, *lockdown.duration* or the number of *siblings* a child had.

Table 4. Factors associated with children's screen time during lockdown using data from the COVID-language dataset (n=1292)

	Estimate	**SE**	***χ2***	***p***
lockdown.severity	-0.230	0.248	0.83	0.361
lockdown.duration	0.029	0.084	0.12	0.732
caregiver.screentime	**0.270**	**0.062**	**10.56**	**0.001**
siblings	-0.080	0.059	1.421	0.233
age (in days)	**1.008**	**0.096**	**25.45**	**0.000**
SES	**-0.424**	**0.095**	**10.69**	**0.001**

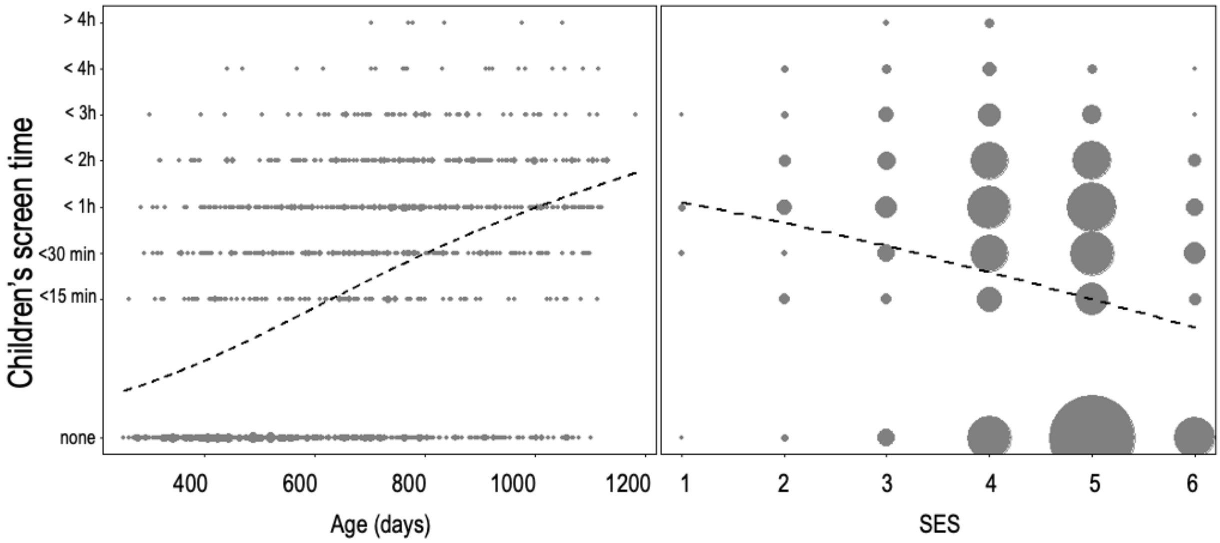


Figure 2: Positive association between children's screen time and age (in days) and negative association between children's screen time and SES (indexed by maternal education; see text for scale) in the COVID-language dataset (n=1292)

As noted above, the COVID-screen dataset (using additional data from Germany, Israel, Switzerland and the UK) included information on whether caregivers agreed with statements about potential positive or negative side effects of their children's screen time. We, therefore, ran an additional model (see **Model 2** specification and additional model parameters in Appendix C) including participants from the COVID-screen dataset who provided information on caregivers' affective response to children's screen time (*caregiver.affect*). We did not include *SES* or *siblings* as a predictor in this model (due to data loss, see Table 2). However, a separate model including *SES* and *siblings* as predictors revealed very similar results to those reported here (see Appendix C, **Model 2.SES**). The model reported here was compared to a null model excluding all predictors as preregistered. While we had originally preregistered including whether the child asked for access to screens to the model we did not include this predictor variable due to almost no countries providing data for this variable.

The full-null model comparison was significant, $\chi 2 = 26.31$, $df = 6$, $p < .001$. Table 5 shows the resulting parameter estimates with the p-values corresponding to drop1 analyses of each of the predictors entered into the model. Note that this model does not include the interaction between *lockdown.severity* and *lockdown.duration* due to this interaction not being significant, $\chi 2 = 0.079$, $df = 1$, $p = .375$, see Model 2 Appendix C). We, therefore, report here the results of a reduced model excluding this interaction to examine potential main effects of *lockdown.severity* and *lockdown.duration*.

The model summary presented in Table 5 suggests a positive association between *caregiver screen time* and *children's screen time* (see Figure 3), as well as *age* of the child and screen time. As in the previous models, we found no associations between *lockdown.severity*, *lockdown.duration* and *siblings* on children's screen time - while the model including *SES* (see Appendix C, Model 2.SES) replicated the negative association between *SES* and children's screen time. Importantly, we found a positive association between caregiver's affective response to screen time and children's screen time (*caregiver.affect*), with caregivers who reported being more positively inclined towards children's screen time also reporting their child having more screen time (see Figure 3).

Table 5. Factors associated with children's screen time during lockdown using data from the COVID-screen dataset ($n = 951$).

	Estimate	**SE**	$\chi 2$	**p**
lockdown.severity	0.304	0.372	0.62	0.432
lockdown.duration	0.005	0.135	0.001	0.971
caregiver.screentime	**0.268**	**0.079**	**6.15**	**0.013**
age (in months)	**0.608**	**0.104**	**9.23**	**0.002**
caregiver.affect	**0.666**	**0.119**	**8.48**	**0.004**

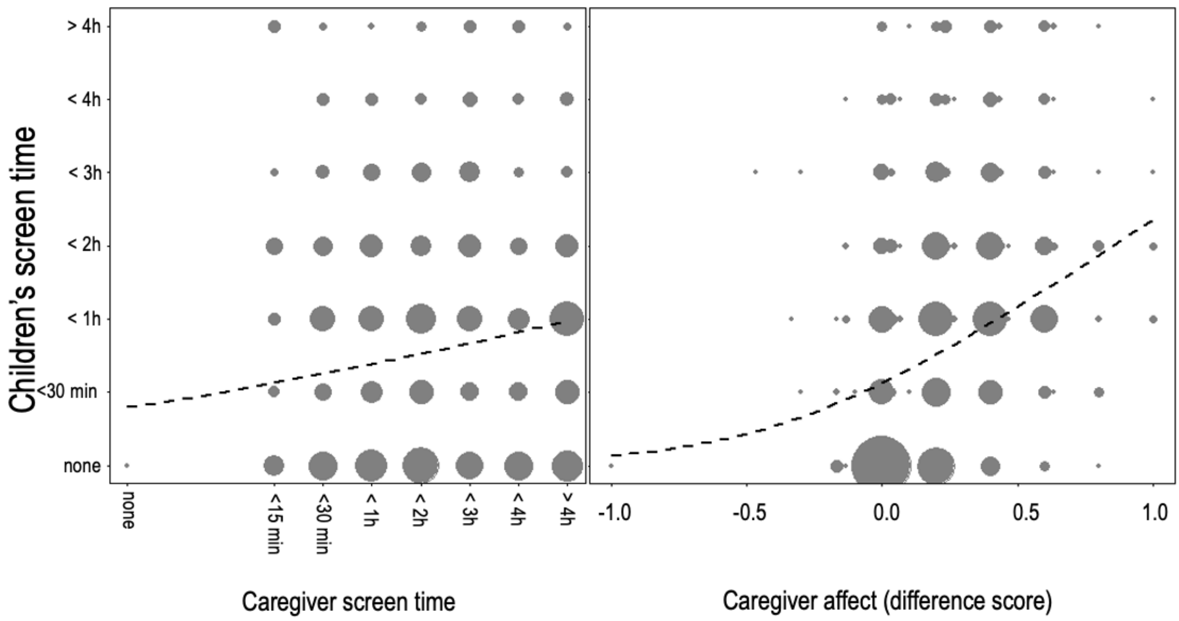


Figure 3: Positive association between children's screen time and caregiver screen time and between children's screen time and caregiver affect to children's screen time in the COVID-screen dataset (n=951)

Differences in Young Children's Screen Time Prior to and During Lockdown

Countries contributing to the COVID-screen dataset (Germany, Israel, Switzerland and the UK) also asked caregivers to provide additional information on how much screen time their children had access to prior to the lockdown as well as during the lockdown. We, therefore, ran an additional model including all participants who provided information on quantity of screen time prior to and during lockdown (see **Model 3** specification and additional model parameters in Appendix C). The factor *lockdown.stage* coded for whether the values indicated for the response variable were for the time prior to the lockdown or during lockdown, with the time prior to lockdown as the reference level. The model reported here was compared to a null model excluding all predictors except *caregiver.affect* as preregistered.

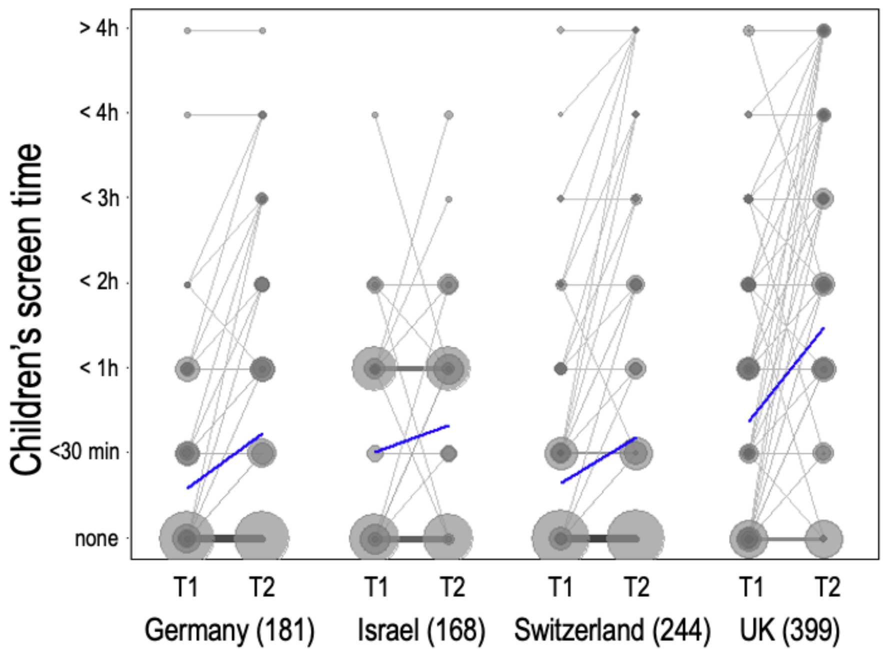


Figure 4. Children's screen time at T1 and T2 of data collection. Circle size indicates proportion within a sample, lines connect paired data and line thickness also signals proportion such that thicker lines reference more common patterns. The blue overlay line indicates mean change to highlight overall trends in the data.

The full-null model comparison was significant, $\chi2$ = 32.95, *df* = 8, *p* <.001. Drop1 analyses suggested a significant interaction between *lockdown.stage* and *lockdown.duration,* $\chi2$ = 4.59, *df* = 1, *p* = .032. There were no interactions between *lockdown.stage* and any of the other predictor variables.

Table 6 shows the resulting parameter estimates with the p-values corresponding to drop1 analyses of the predictors entered into the model. As Figure 5 suggests, children had more access to screen time during lockdown relative to before the lockdown and this increase was particularly exacerbated for children from countries with longer lockdowns. However, Figure 5 also suggests an increase in screen time in countries with longer lockdowns prior to the start of lockdown, which we attribute tentatively to country-specific differences in screen time and lockdown duration. There was no evidence that increases in screen time during lockdown were associated with the other predictors included. We note that the model on a reduced dataset including *SES* and *siblings* as predictors failed to converge.

Table 6. Differences in children's screen time prior to and during lockdown (n=953)

	Estimate	**SE**	***χ2***	**p**
lockdown.stage	1.930	0.324		
lockdown. severity	0.734	0.378		
lockdown.duration	-0.456	0.255		
age (in months)	1.155	0.214		
caregiver.affect	1.335	0.250		
lockdown.stage:lockdown.severity	-0.140	0.331	0.179	0.672
lockdown.stage:lockdown.duration	**0.439**	**0.207**	**4.589**	**0.032**
lockdown.stage:age	0.218	0.113	2.388	0.122
lockdown.stage:caregiver.affect	0.233	0.146	1.964	0.161

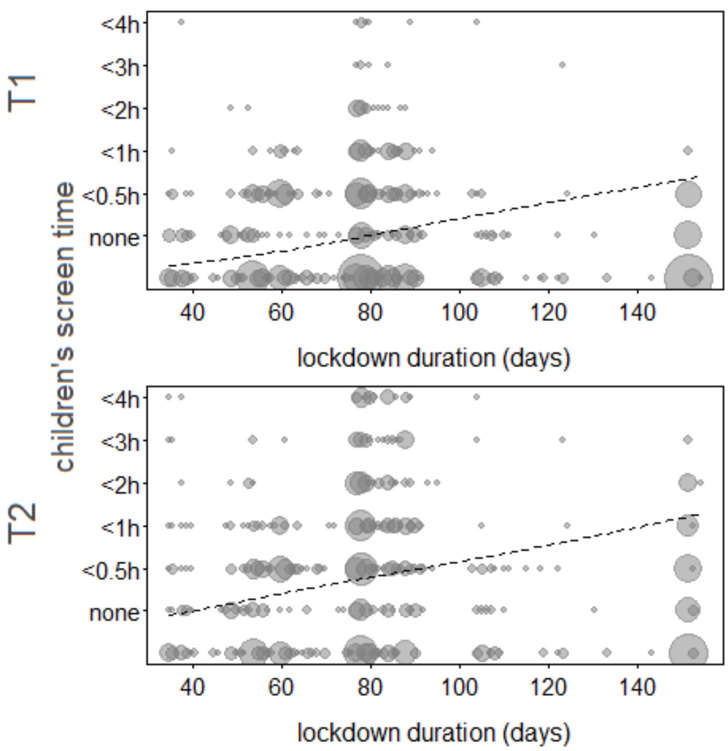


Figure 5. Children's screen time at T1 (top) and T2 (bottom) by lockdown duration (in days), the dashed line indicates the model estimates.

Lockdown-Related Surge in Screen Time and Vocabulary Development

Finally, we examined whether lockdown-related increases in children's screen time impacted children's vocabulary development, such that those children who were reported to have had more screen time during lockdown were also reported to show smaller gains in vocabulary development during lockdown. The response variables entered into separate receptive and expressive vocabulary models were children's receptive and expressive percentile scores respectively (see **Model 4a/b** specification and additional model parameters in Appendix C). The models reported here were compared to null models excluding all predictors except *SES* as preregistered.

The full-null model comparison for the receptive model was not significant, $\chi2$ = 13.02, df = 7, p =.072, while the full-null model comparison for the expressive model was significant, $\chi2$ = 14.92, df = 7, p =.037. Table 7 shows the resulting parameter estimates with the p-values corresponding to drop1 analyses of each of the predictors entered into the model. Table 7 shows a reduced model including only the interaction between *lockdown.stage* and *screen.time* given that this interaction was near-significant in the full model described above, $\chi2$ = 3.52, df = 1, p =.060 (see model 4b parameters in Appendix C). While the results in Table 7 with regards to the significant interaction between *lockdown.stage*screen.time* should be treated with caution due to the marginal effect in the full model, they suggest that those children who had reduced screen time during lockdown relative to prior to lockdown were reported to have larger increases in expressive vocabulary during lockdown (see Figure 6).

Table 7. Association between increase in screen time during lockdown and expressive vocabulary development (n=156) and receptive vocabulary development (n=117). Note that drop1 analyses failed to converge for the predictor *age*. Hence we report z and p values from the summary model output for this predictor variable.

	Expressive vocabulary				**Receptive vocabulary**			
	Estimate	**SE**	***χ2***	***p***	**Estimate**	**SE**	***χ2***	***p***
lockdown.stage	.323	.091						
screen.time	.024	.111						
SES	-.037	.103	.13	.732	.108	.105	.71	.398
caregiver.affect	.007	.102	.00	.001	-.091	.129	.50	.480
age (in months)	.188	.100	1.87	.062	-.031	.116	.08	.783
lockdown.stage: screen.time	**-.217**	**.096**	**4.63**	**.031**	-.144	.078	3.16	.075

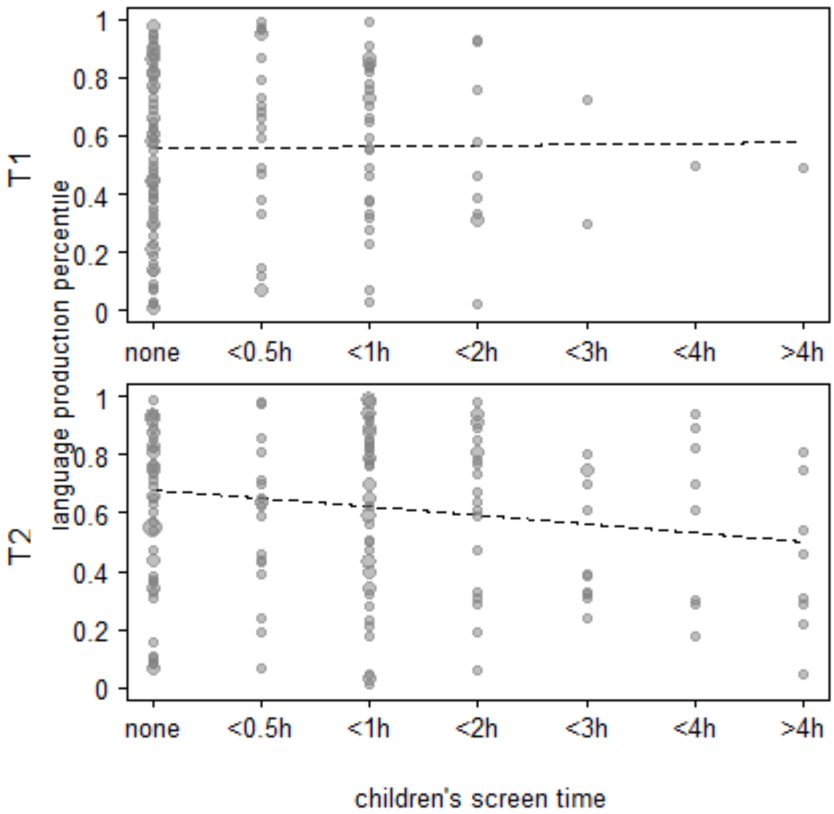


Figure 6. Expressive vocabulary size and children's screen time before lockdown (T1) and during lockdown (T2).

Discussion

This study examined 8-36-month-old infants' and toddlers' screen time during the first COVID-19 lockdown. With regards to the factors associated with young children's screen time during lockdown, we found that children have exposure to screens from very early on: From as early as eight months of age, *some* children appear to have regular daily exposure to screens. Nevertheless, we found that screen time increased with age, with older children reported to have more screen time than younger children. This effect was consistent across the two datasets and the literature (Alroqi et al., in press; Bedford et al., 2016; Nevski & Siibak, 2016; Paudel et al., 2017; Rideout & Robb, 2020). Socioeconomic status (SES), as indexed by maternal education, was negatively associated with screen time, with caregivers from lower SES families reporting that their children had more screen time than caregivers from higher SES families, although we note that our sample was biased towards higher SES families. Therefore, this finding may not generalize to the wider population.

We also found a positive association between children's and caregivers' screen time consistent with the literature (Nevski & Siibak, 2016). Probing this relation further, caregivers' beliefs about the impact of screen time (e.g., that children's screen time allows them contact with others outside the family, or leads to fights between siblings) was associated with increased children's screen time, such that caregivers who were more positively inclined to screen time also reported allowing their children more screen time. This finding may suggest that caregivers' attitudes towards children's screen time predict the extent of children's screen time exposure. However, we note that an alternative explanation of this association may be that those caregivers who were more positively inclined towards children's screen time were also more likely to report that their child had access to screen time, due to their not viewing this activity negatively. Our results are unable to tease apart these two explanations.

Furthermore, as Figure 4 suggests, we found that even young infants and toddlers were reported to have had more screen time during lockdown relative to the period before lockdown. While this echoes previous results with older children (see Table 1), increases in screen time during lockdown in school-aged children are likely related to enforced online schooling. Here, we found that, despite young infants and toddlers having no online schooling requirements, even these youngest members of our society had increased exposure to screens during lockdown. There was some evidence that this increase in screen time during lockdown was related to the duration of lockdown in specific countries, such that children from countries who enforced longer lockdowns had increased screen time relative to children from countries with shorter lockdowns. This finding highlights how differences in environmental factors, such as, for instance, restrictions during lockdown on activities that families typically engaged in, can impact children's screen time early in development. Thus, the longer caregivers were at home caring for their children while also working from home; with limited access to other activities to occupy their charges, the more screen time their children reportedly had access to. However, we found no evidence that increases in screen time during lockdown were associated with other sociodemographic characteristics such as SES or the age of the child.

Finally, we discuss the potential impacts of increased screen time on children's development during lockdown, particularly with regard to children's vocabulary development. A study on children (Kartushina et al., 2021) at the same age as those reported here found that children's gains in expressive vocabulary size during lockdown were negatively associated with children's screen time. Extending these findings, we found tentative evidence for the hypothesis that children who experienced larger increases in screen time during lockdown relative to before lockdown showed smaller increases in their expressive vocabulary during lockdown, such that their language development was on par with, but not exceeding, expected growth. While this finding suggests that abrupt changes in children's daily lives may have consequences for their language development, we note that these results should be treated with caution due to the exploratory nature of the analyses. Nevertheless, these findings raise questions regarding why screen time, especially with regards to suddenly increased screen time during the lockdown, is negatively associated with language and other developmental milestones. While some explanations for similar findings target the difficulties infants and toddlers face when learning words from screens, others target potential negative effects of screen time with regards to the fact that screen time may displace time spent on other enriching activities. For instance, children who have increased exposure to television, spend less time reading or being read to (Khan et al., 2017; Vandewater et al., 2005), and have fewer books at home (Linebarger et al., 2013).

Conclusions

This study highlights the consequences of the COVID-19 pandemic on early development. On the one hand, we found that young infants and toddlers with no online schooling requirements were exposed to more screen time during lockdown relative to prior to lockdown. We also found tentative evidence that this may have been particularly exacerbated in countries with longer lockdowns. On the other hand, we found that factors previously associated with screen time before the lockdown in the literature were associated with screen time during lockdown in the current study (i.e., the age of the child, SES, caregiver screen time and caregiver attitude to screen time). We interpret this in terms of the continuity of the presence of screens in young children's lives. The COVID-19 pandemic provided us a unique window to explore the changes in children's lives, and to examine sources of individual differences as well as cultural differences in screen time in young children. These findings shed light on the way different families view, use and are affected by screens in both their normal and disrupted lives.

Author contributions

ND and NM conceived and planned the study in the context of a larger study on COVID-19 and language development (Kartushina et al., 2021, see details on author contributions there). ND and NM created the materials for the questionnaire on screen time. CB, ND and NM managed the project. NM wrote the preregistration with comments from SA, HA, MB, CB, THK, JM and JS. ND, KA, AA, HA, SA, CD, CK, NGG, SG, NH, THK, JK, NK, JM, JS and NM collected data for the manuscript and ND, SA, CD, CK, NGG, SG, NH, THK, JS and NM collected additional data on screen time for the manuscript. CB and RM preprocessed the data. CB, JM, RM and NM created visualizations. NM took the lead in writing the manuscript with significant contributions from ND, KA, HA, SA, MB, CB, CD, NGG, SG and JK. AA, HA, KA, CB and JK and NM edited and prepared the manuscript for submission. All authors provided critical feedback and commented on the manuscript.

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Appendix A: Questions related to caregivers' perception of potential positive and negative side-effects of children's screen time

Positive side-effects of screen time: Does your child's use of screens help you?

- No
- It frees me up time to work/ telecommute/ do household chores
- It frees up time for me
- This allows my child to have contact with family/friends
- It allows me to calm my child
- It allows me to create a bond with my child.

Negative side-effects of screen time: Does your child's use of screens cause you difficulties?

- No
- I have trouble feeding my child
- My child has trouble falling asleep
- Screens lead to siblings fighting with one another
- My child is restless
- Screens lead to caregivers fighting with one another
- Screens make it difficult to interact with my child

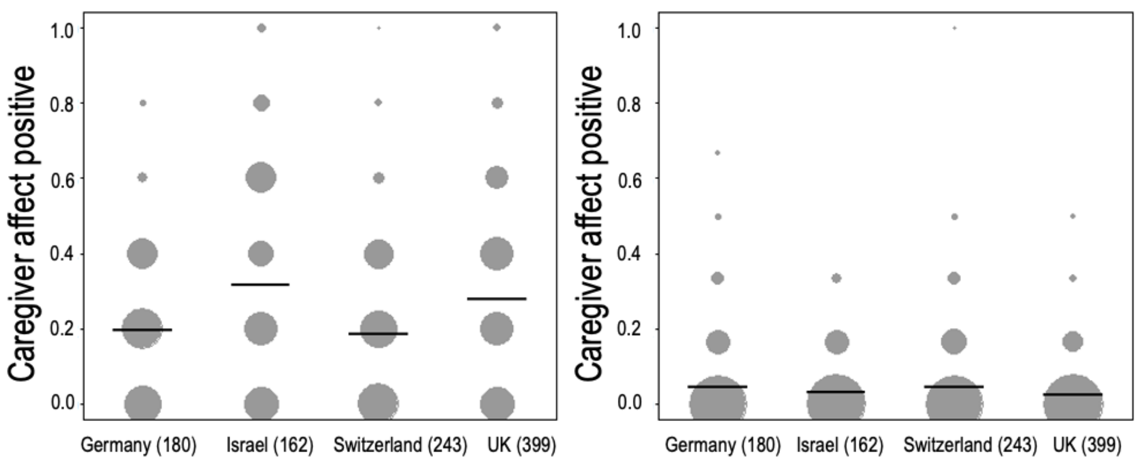
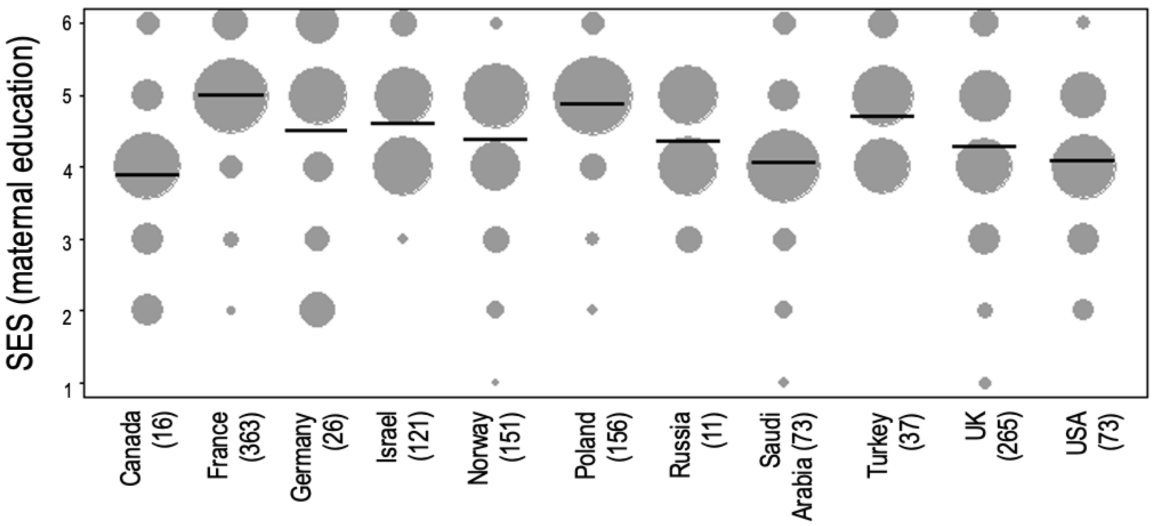


Figure A1. Caregiver's perception of positive (caregiver affect positive) and negative side-effects (caregiver affect negative) of children's screen time in the COVID-screen dataset

Appendix B: Additional Figures

Figure B1. Maternal education as a proxy for socioeconomic status of the children contributing to (A) COVID-language dataset and (B) COVID-screen dataset. This was measured on a scale from 1 to 6 as follows: 1 (primary school), 2 (high school), 3 (college/University), 4 (Bachelor degree), 5 (Master degree), 6 (Doctoral degree). Circle size refers to proportions within a country, solid black lines are means to highlight trends in the data.

(A)



(B)

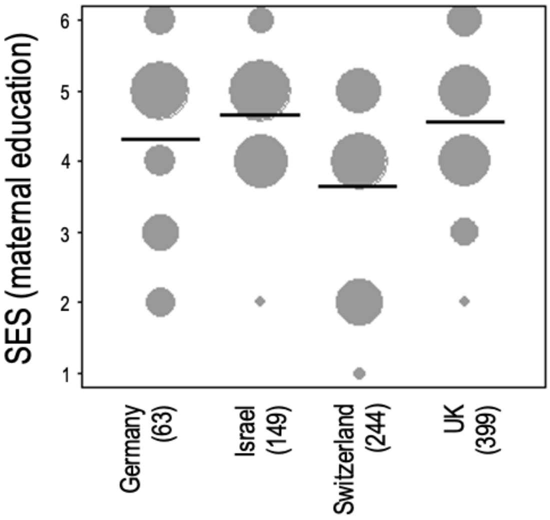
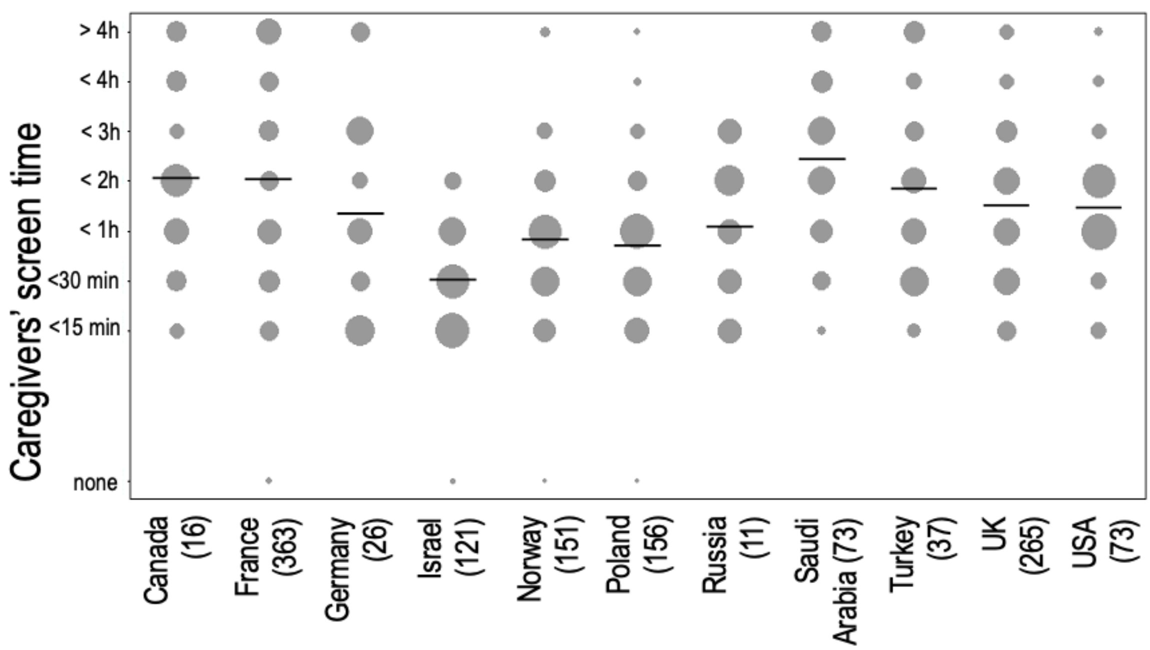

SES (maternal education)
6
5
4
3
2
1
Germany (63)
Israel (149)
Switzerland (244)
UK (399)

Figure B2. Caregivers' reports of their own screen time using data from (A) COVID-language dataset and (B) COVID-screen dataset. Note that datapoints that did not fall in the monotonous scale preregistered for the current study (i.e., duration of screen time per week (1-2/w and 3-4/w) were excluded from the analysis. Circle size refers to proportions within a country, solid black lines indicate means to highlight trends in the data.

(A)



(B)

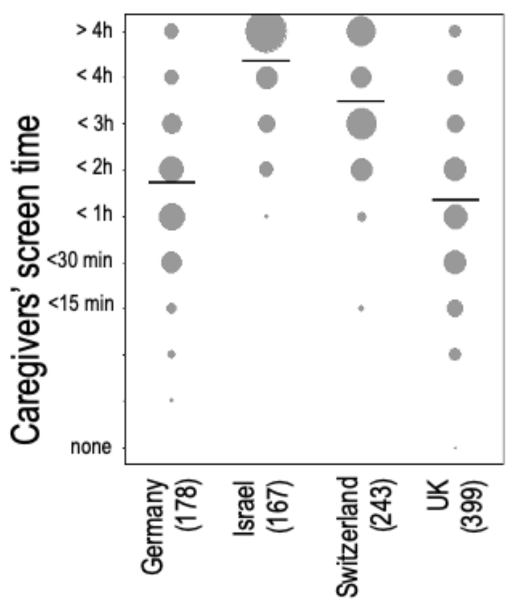
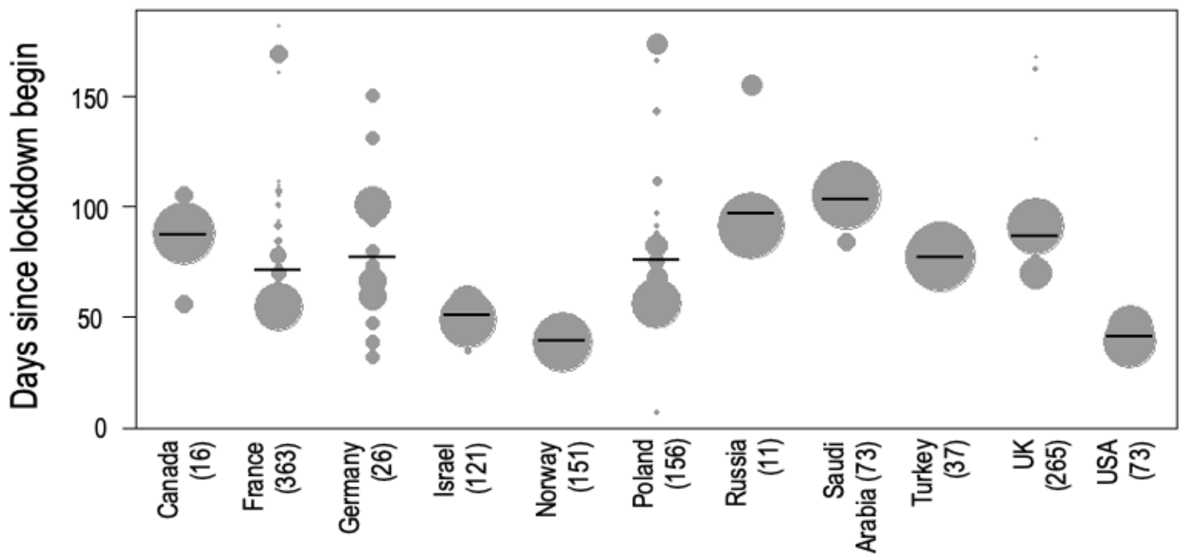
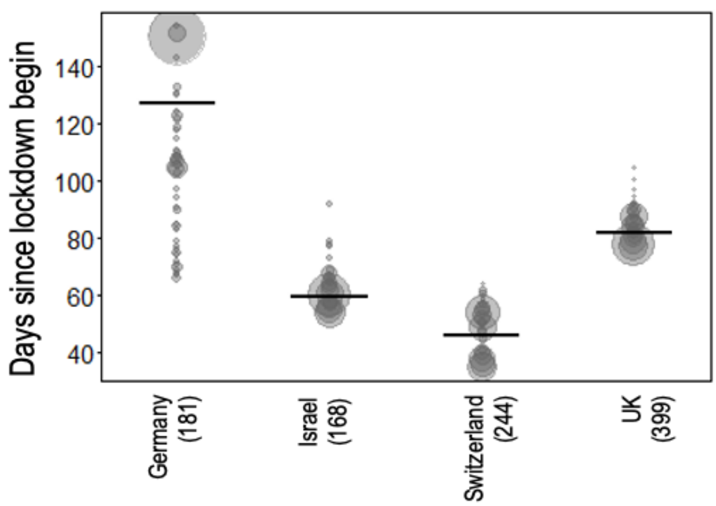


Figure B3. Lockdown duration in the countries contributing to (A) COVID-language dataset and (B) COVID-screen dataset. Note that this was calculated based on the number of days between the date on which the T2 questionnaire was filled (the end of lockdown for that family due to the child starting daycare again or the end of data collection if lockdown was not yet complete) and the date on which nurseries, preschools and daycares shut in that region or country. Circle size refers to proportions within a country, solid black lines indicate means to highlight trends in the data.

(A)



(B)



Appendix C: Model specification and parameters

Model specification, output and means of *scaled* predictor variables for interpretation of the estimates. Likelihood ratios and p values refer to drop1 analyses.

Model 1:

Full model: screen.time ~ lockdown.severity*lockdown.duration + caregiver.screentime + siblings + age + SES + (1 | country)+(0 + caregiver.screentime | country)+(0 + siblings | country)+(0 + age | country)+(0 + SES | country)+(0 + z.lockdown.duration | country)

	Estimate	**SE**	***χ2***	***p***	**Mean**
lockdown.severity	-0.245	0.242			-6.07
lockdown.duration	0.090	0.083			2.24
caregiver.screentime	**0.269**	**0.062**	**10.46**	**0.001**	**4.24**
siblings	-0.080	0.059	1.40	0.238	
age	**1.017**	**0.099**	**25.10**	**0.000**	**-2.46**
SES (maternal education)	**-0.424**	**0.095**	**10.71**	**0.001**	**3.64**
lockdown.severity: lockdown.duration	0.107	0.063	2.83	0.093	

Reduced model (excluding non-significant interaction between lockdown.severity and lockdown.duration): screen.time ~ lockdown.severity + lockdown.duration + caregiver.screentime + siblings + age + SES + (1 | country)+(0 + caregiver.screentime | country)+(0 + siblings | country)+(0 + age | country)+ (0 + SES | country)+(0 + z.lockdown.duration | country)

	Estimate	**SE**	***χ2***	***p***
lockdown.severity	-0.230	0.248	0.83	0.361
lockdown.duration	0.029	0.084	0.12	0.732
caregiver.screentime	**0.270**	**0.062**	**10.56**	**0.001**
siblings	-0.080	0.059	1.42	0.233
age	**1.008**	**0.096**	**25.45**	**0.000**
SES (maternal education)	**-0.424**	**0.095**	**10.69**	**0.001**

Model 2:

Full model: screen.time ~ lockdown.severity*lockdown.duration + caregiver.screentime + age + caregiver.affect + (1 | country)+(0 + caregiver.screentime | country)+(0 + age | country)+(0 + age | country)+(0 + caregiver.affect | country)

	Estimate	SE	χ2	*p*	Mean
lockdown.severity	0.482	0.396			-1.140
lockdown.duration	0.036	0.138			-1.726
caregiver.screentime	**0.266**	**0.079**	**6.12**	**0.013**	**-8.922**
age (in months)	**0.604**	**0.104**	**9.19**	**0.002**	**8.544**
caregiver.affect	**0.664**	**0.118**	**8.53**	**0.003**	**6.620**
lockdown.severity: lockdown.duration	0.246	0.277	0.79	0.375	

Reduced model (excluding non-significant interaction between lockdown.severity and lockdown.duration): screen.time ~ lockdown.severity+lockdown.duration + caregiver.screentime + age + caregiver.affect + (1 | country)+(0 + caregiver.screentime | country)+(0 + age | country)+(0 + age | country)+(0 + caregiver.affect | country)

	Estimate	SE	χ2	*p*
lockdown.severity	0.304	0.372	0.62	0.432
lockdown.duration	0.005	0.135	0.001	0.971
caregiver.screentime	**0.268**	**0.079**	**6.15**	**0.013**
age (in months)	**0.608**	**0.104**	**9.23**	**0.002**
caregiver.affect	**0.666**	**0.119**	**8.48**	**0.004**

Model 2.SES:

Full model: screen.time ~ lockdown.severity*lockdown.duration + caregiver.screentime + age + caregiver.affect + SES + siblings + (1 | Country)+(0 + caregiver.screentime | Country)+(0 + age | Country)+ (0 + caregiver.affect | Country))+(0 + SES | country))+(0 + siblings | country)

	Estimate	SE	χ2	*p*	Mean
lockdown.severity	0.502	0.432			1.308
lockdown.duration	0.112	0.249			-7.305
caregiver.screentime	**0.304**	**0.099**	**4.67**	**0.031**	**-6.337**

siblings	0.157	0.083	2.09	0.148	3.732
age	**0.551**	**0.147**	**5.13**	**0.024**	**-1.682**
caregiver.affect	**0.645**	**0.081**	**9.84**	**0.002**	**-4.910**
SES (maternal education)	**-0.294**	**0.083**	**4.31**	**0.038**	**-2.158**
lockdown.severity: lockdown.duration	0.072	0.187	0.15	0.701	

Reduced model (excluding non-significant interaction between lockdown.severity and lockdown.duration): screen.time ~ lockdown.severity + lockdown.duration + caregiver.screentime + age + caregiver.affect + SES + siblings + (1 | Country)+(0 + caregiver.screentime | Country)+(0 + age | Country)+ (0 + caregiver.affect | Country))+(0 + SES | country))+(0 + siblings | country)

	Estimate	SE	*χ2*	*p*
lockdown.severity	0.431	0.409	0.98	0.322
lockdown.duration	0.077	0.230	0.11	0.736
caregiver.screentime	**0.305**	**0.099**	**4.71**	**0.030**
siblings	0.155	0.083	1.98	0.160
age	**0.549**	**0.144**	**5.21**	**0.023**
caregiver.affect	**0.645**	**0.081**	**9.72**	**0.002**
SES (maternal education)	**-0.291**	**0.083**	**4.20**	**0.040**

Model 3: screen.time ~ lockdown.stage*(caregiver.affect + age + lockdown.severity+ lockdown.duration) + (1| Country)+(0+lockdown.stage| Country)+(0+age| Country)+(0+caregiver.affect| Country)+(0+I(lockdown.stage*age)| Country)+(0+I(lockdown.stage*caregiver.affect)| Country)+(1| subject)

	Estimate	SE	*χ2*	*p*	Mean
lockdown.stage	1.930	0.324			
lockdown. severity	0.734	0.378			6.98
lockdown.duration	-0.456	0.255			8.07
age	1.155	0.214			2.19
caregiver.affect	1.335	0.250			3.58
lockdown.stage: lockdown.severity	-0.140	0.331	0.18	0.672	
lockdown.stage: lockdown.duration	**0.439**	**0.207**	**4.59**	**0.032**	

lockdown.stage:age	0.218	0.113	2.39	0.122
lockdown.stage: caregiver.affect	0.233	0.146	1.96	0.161

Model 4a:

Full model: receptive vocabulary size ~ lockdown.stage*(screen.time + age + caregiver.affect) + SES + (1| Country)+(0+lockdown.stage | Country)+(0+screen.time| Country)+(0+SES| Country)+ (0+age| Country)+(0+caregiver.affect| Country)+ (0+I(lockdown.stage*screen.time)| Country)+ (0+I(lockdown.stage*age)| Country)+(0+I(lockdown.stage*caregiver.affect)| Country)+ (1| subject)

	Estimate	SE	*χ2*	*p*	Mean
lockdown.stage	0.332	0.081			
screen.time	0.094	0.105			7.72
age	-0.100	0.133			-1.41
caregiver.affect	-0.127	0.134			-2.00
SES (maternal education)	0.098	0.127	0.59	0.443	4.68
lockdown.stage:screen.time	**-0.165**	**0.079**	**3.84**	**0.050**	
lockdown.stage:age	0.087	0.084	1.07	0.301	
lockdown.stage.code: caregiver.affect	0.064	0.067	0.93	0.334	

Reduced model (excluding non-significant interaction between lockdown.stage and age and caregiver.affect): receptive vocabulary size ~ lockdown.stage*screen.time + age + caregiver.affect + SES + (1| Country)+(0+lockdown.stage | Country)+(0+screen.time| Country)+(0+SES| Country)+ (0+age| Country)+(0+caregiver.affect| Country)+ (0+(lockdown.stage*screen.time)| Country)+(1| subject)

	Estimate	SE	*χ2*	*p*
lockdown.stage				
screen.time				
SES	0.108	0.105	0.71	.398
caregiver.affect	-0.091	0.129	0.50	.480
age	-0.031	0.116	0.08	.783
lockdown.stage: screen.time	-0.144	0.078	3.16	.075

Model 4b:

Full model: expressive vocabulary size ~ lockdown.stage*(screen.time + age + caregiver.affect) + SES + (1| Country)+(0+lockdown.stage | Country)+(0+screen.time| Country)+(0+SES| Country)+ (0+age| Country)+(0+caregiver.affect| Country)+ (0+I(lockdown.stage*screen.time)| Country)+ (0+I(lockdown.stage*age)| Country)+(0+I(lockdown.stage*caregiver.affect)| Country)+ (1| subject)

	Estimate	**SE**	***χ2***	***p***	**Mean**
lockdown.stage	0.321	0.091			
screen.time	0.023	0.111			-2.66
age	0.061	0.113			-6.92
caregiver.affect	0.213	0.115			6.40
SES (maternal education)	-0.032	0.103	0.095	0.758	2.98
lockdown.stage:screen.time	*-0.191*	*0.100*	*3.524*	*0.060*	
lockdown.stage:age	-0.096	0.083	1.319	0.251	
lockdown.stage.code: caregiver.affect	-0.036	0.085	0.179	0.672	

Reduced model (excluding non-significant interaction between lockdown.stage and age and caregiver.affect): expressive vocabulary size ~ lockdown.stage*screen.time + age + caregiver.affect + SES + (1| Country)+(0+lockdown.stage | Country)+(0+screen.time| Country)+(0+SES| Country)+ (0+age| Country)+(0+caregiver.affect| Country)+ (0+(lockdown.stage*screen.time)| Country)+(1| subject)

	Estimate	**SE**	***χ2***	***p***
lockdown.stage	0.323	0.091		
screen.time	0.024	0.111		
SES	-0.037	0.103	0.13	0.732
caregiver.affect	0.007	0.102	0.004	0.001
age	0.188	0.100		
lockdown.stage:screen.time	-0.217	0.096	4.63	0.031