

Online Research @ Cardiff

This is an Open Access document downloaded from ORCA, Cardiff University's institutional repository: <https://orca.cardiff.ac.uk/id/eprint/125528/>

This is the author's version of a work that was submitted to / accepted for publication.

Citation for final published version:

Przybylski, A, DPhil, AO and Weinstein, Netta ORCID: <https://orcid.org/0000-0003-2200-6617> 2020. How much is too much? Examining the relationship between digital screen engagement and psychosocial functioning in a representative cohort study. *Journal of the American Academy of Child and Adolescent Psychiatry* 59 (9) , pp. 1080-1088. 10.1016/j.jaac.2019.06.017 file

Publishers page: <http://dx.doi.org/10.1016/j.jaac.2019.06.017>
<<http://dx.doi.org/10.1016/j.jaac.2019.06.017>>

Please note:

Changes made as a result of publishing processes such as copy-editing, formatting and page numbers may not be reflected in this version. For the definitive version of this publication, please refer to the published source. You are advised to consult the publisher's version if you wish to cite this paper.

This version is being made available in accordance with publisher policies.
See

<http://orca.cf.ac.uk/policies.html> for usage policies. Copyright and moral rights for publications made available in ORCA are retained by the copyright holders.



How Much Is Too Much? Examining the Relationship Between Digital Screen Engagement and Psychosocial Functioning in a Confirmatory Cohort Study

Andrew K. Przybylski, PhD, Amy Orben, DPhil, Netta Weinstein, PhD

Objective: Previous studies have offered mixed results regarding the link between digital screen engagement and the psychosocial functioning of young people. In this study, we aimed to determine the magnitude of this relation, to inform the discussion regarding whether amount of digital screen time has a subjectively significant impact on the psychosocial functioning of children and adolescents.

Method: We analyzed data from primary caregivers participating in the National Survey of Children's Health (NSCH), an annual nationally representative survey fielded by the US Census Bureau between June 2016 and February 2017. NSCH uses an address-based sampling frame and both Web- and paper-based data collection instruments to measure psychosocial functioning and digital engagement, including a modified version of the Strengths and Difficulties questionnaire and caregiver estimates of daily television- and device-based engagement, respectively.

Results: The expected parabolic inverted-U-shaped relationship linking digital screen engagement to psychosocial functioning was found. These results replicated past findings suggesting that moderate levels of screen time (1-2 hours a day) were associated with slightly higher levels of psychosocial functioning compared to lower or higher levels of engagement. Furthermore, it indicated that children and adolescents would require 4 hours 40 minutes of television-based engagement and 5 hours 8 minutes of daily device-based engagement before caregivers would be able to notice subjectively significant variations in psychosocial functioning.

Conclusion: The possible influence of digital screen engagement is likely smaller and more nuanced than we might expect. These findings do not rule out the possibility that parents might only notice very high levels of screen time when their child manifests pronounced psychosocial difficulties. Future work should be guided by transparent and confirmatory programs of research.

Key words: digital screen time, digital devices, psychosocial functioning

J Am Acad Child Adolesc Psychiatry 2020;59(9):1080–1088. 

Advances in technology have increased the ubiquity and utility of digital devices, making them an inescapable feature of everyday life.¹ Ease of use and reduced cost allow growing populations of young people to access digital devices, games, and online platforms.² As the share of time that children and adolescents spend using such digital devices has increased, so too have the concerns about the relationship of these devices with mental health and psychosocial functioning.³ Given the absence of compelling evidence linking digital screen engagement to psychosocial functioning, professional guidance provided to caregivers and educators has been predominately shaped by a sense of precaution that prioritizes digital engagement limits. This first took the form of the “2x2 Rule,” advice that children <2 years of age should have no screen time, and children more than 2 years of age should be limited to ≤ 2 of daily digital engagement.⁴ Unfortunately, there was insufficient evidence

supporting this guidance,^{5,6} and research on caregivers found that the guidance was difficult to follow, given the many advantages of digital technology, such as video chat with family and friends.⁷

Professional organizations in the West rethought this advice in 2016, introducing guidance focusing on the quality of screen time and favoring family diaries of digital engagement.⁸ Responses to concerns about digital engagement and psychosocial functioning vary around the globe. South Korea's 2011 “Shutdown Law,” for example, restricted youth access to online platforms, including games and social media, between midnight and 6 in the morning.⁹ This legislation aimed to reduce technology addiction and to bolster sleep. It was in place for nearly 6 years before research gauging its effectiveness indicated that it did not achieve either of these goals. In both cases, professional advice and legislative action fell short of positively affecting

youth mental health and functioning because change was pursued without the necessary scientific support.⁹

Most existing research examining the impact of digital engagement focuses on concerns regarding relations between digital engagement and pediatric outcomes. A number of these studies have identified small associations (eg, r values <0.10), suggesting that digital engagement might displace opportunities for physical activity^{10,11} and the learning of essential skills.¹² Evidence from longer-term longitudinal studies, with robust covariates, indicate that potential displacement is inconsistent: those who reported the highest levels of noninteractive forms of engagement, such as watching television (TV), showed slightly lower levels (about 0.09 SD) of psychological functioning at follow-up, but this relationship was entirely absent for interactive activities such as gaming.¹³ Many studies, however, have failed to show any relations linking media use and learning in young children.^{14,15}

Two recent studies, 1 focused on British adolescents and another with young American children, indicate that the relations between digital screen engagement and psychosocial outcomes are nonlinear.^{16,17} The idea that parabolic function links digital engagement to mental well-being, dubbed the “Goldilocks hypothesis,” has received some empirical support. Briefly, moderate levels of digital screen time (1-2 hours a day) may be associated with slightly higher levels of key outcomes compared to engagement at either lower or higher levels. Although this hypothesis makes intuitive sense, as many apps and digital technologies are useful for informing and connecting young people, results have not uniformly supported it.⁵ Where research has identified parabolic trends, the average correlates of positive or negative digital engagement found in this previous research are very small, accounting for $>1\%$ of variability in child outcomes.¹⁸ In other words, although many of these relations are statistically significant, more than 99% of variability in psychosocial outcomes is unrelated to digital engagement. This pattern of results highlights a disconnect between the statistically significant relations identified in the literature and relations that could be understood as relevant to caregivers, policymakers, or health professionals. This gap is a challenge for evidence-based health policymaking for children in the digital age.

This issue centers on the degree to which statistical significance, whether a hypothesis test rejects the null hypothesis, provides compelling evidence that digital technology influences young people. This assumption has not been empirically supported. Ferguson (2009)³⁹ argued that not all statistically significant media effects are practically significant; instead, he proposed a minimum effect, equivalent to a standardized Cohen d of 0.41, for those

studying the impact of digital media on users. Ferguson argued for this Smallest Effect Size of Interest (SESOI), in part, because digital media engagement measures and self-report outcomes are imperfect.¹⁹ He also cautioned researchers to be context specific, weighing the merits and potential unreliability of study methodology against potential real-world impact. This advice mirrors a broader literature concerned with subjective effects that focuses on Minimally Important Differences (MIDs).^{20,21} Researchers interested in practically significant effects select a minimum threshold for an association on the basis of whether someone can consistently report an internal state. Reviews of the literature suggest a Cohen d of 0.50 is the smallest difference that research subjects and patients can reliably distinguish in pain, functioning, and health outcomes. The MID, therefore, provides an empirically grounded gauge of the extent to which excessive digital screen time has a subjectively significant effect. Instead of relying on statistical significance, we can use the MID cutoff to derive the point at which digital screen engagement starts to have an association with psychosocial functioning that a caregiver could possibly notice.

With this in mind, the goal of the present research was to rigorously investigate the association between digital screen time and psychosocial functioning, to determine the magnitude of this link. To this end, we analyzed data from two nationally representative cohort data sets to examine the linear and parabolic relations between technology use and pediatric outcomes.¹⁶ Our goals were twofold. First, we wanted to conduct a rigorous confirmatory test of the Goldilocks hypothesis using a North American sample reflecting experiences of a wider range of young people aged 6-17 years. Second, we aimed to empirically identify the point at which digital engagement might relate to psychosocial functioning at a level that a caregiver might be able to reliably detect. To avoid potential problems with researcher degrees of freedom, a problem known to influence what we understand about the relations linking technology use to youth outcomes,²² we analyzed well-validated measures of screen time and psychosocial functioning, defining a number of key control variables at the individual, family, and community levels, and data analysis was preregistered to provide a confirmatory replication of previous approaches.

METHOD

The primary data analyzed were derived from self-report surveys completed by caregivers living in the United States as part of the 2016 National Survey of Children's Health (NSCH). Conducted on behalf of the US Department of Health and Human Services, Health Resources and Services Administration's Maternal and Child Health

Bureau, the NSCH uses an address-based sampling frame and both Web-based and mailed paper data collection instruments fielded by the US Census Bureau.²³ Fieldwork was conducted between June 2016 and February 2017, and the data collected reflect a nationally representative sample of children and young people living in all 50 states and the District of Columbia. State-level responses ranged from a low of 638 (Missouri) to a high of 1,351 (Minnesota). Caregivers spent 35 minutes, on average, completing either a paper questionnaire (9,719; 19.4%) or an online instrument (40,493; 80.6%), answering questions about themselves, their households, and children and adolescents. The full sample was evenly divided between male (n = 25,733, 51.2%) and female (n = 24,479, 48.8%) individuals.

Ethical Review and Open Science Practices

Ethical review was conducted by The US Department of Health and Human Services, and study data are available online on the Centers for Disease Control and Prevention (CDC) website.²³ All of the codes required to restructure and analyze these data are available for download on the Open Science Framework.²⁴

Measures for Outcome Variable

Psychosocial Functioning. Caregivers completed an adapted version of the Strengths and Difficulties Questionnaire, a widely used measure of adolescents' social and emotional functioning that has been validated in a range of community,²⁵ academic,²⁶ and clinical settings.²⁷ Caregivers used a three-point scale ("Definitely true", "Somewhat true", "Not true") to rate how eight items reflected their child's strengths (eg, "This child works to finish tasks that he or she starts") and difficulties (eg, "This child bullies others, picks on them, or excludes them"). In line with the analysis plan, the scale demonstrated good internal reliability. Individual scores were computed by reverse coding negatively worded items and averaging across responses (mean = 2.70, SD = 0.33, $\alpha = 0.79$).

Measures for Explanatory Variables

TV-Based Engagement. Caregivers estimated their child's daily engagement with TV-based activities by responding to the item: "On an average weekday, about how much time does [child name] usually spend in front of a TV watching TV programs, videos, or playing video games?" using a 6-point scale ranging from "none" to "4 or more hours." Nearly all caregivers responded (98.9%, n = 35,310). On average, young people spent 1 hour 41 minutes (SD = 1 hour 4 minutes) a day in TV-based engagement. Table 1, left, presents the observed frequencies.

TABLE 1 Observed Frequencies of Daily TV-Based and Device-Based Engagement

Daily Hours	TV-based engagement		Device-based engagement	
	n	%	n	%
0	1,455	4.1	1,380	3.9
<1	5,966	16.9	5,640	16.0
1	9,820	27.8	8,565	24.2
2	10,603	30.0	9,429	26.7
3	4,358	12.3	4,786	13.5
>4	3,108	8.8	5,535	15.7

Note: Percentages reflect values across all valid responses. TV = television.

Device-Based Engagement. Caregivers estimated their child's daily engagement with device-based activities by responding to the item: "On an average weekday, about how much time does [your child] usually spend with computers, cell phones, handheld video games, and other electronic devices?" using the same scale as was used to measure TV-based engagement. Nearly all caregivers responded (98.9%, n = 35,335), and they reported that the young persons spent an average of 1 hour 53 minutes (SD = 1 hour 13 minutes) on device-based engagement. Table 1, right, presents the observed frequencies.

Measures for Control Variables

Because previous research suggests that digital engagement and psychosocial functioning may be correlated with child-, family-, and community-level variables, a series of control variables were included in the hypothesis-testing models detailed in the analysis plan. Adjusting for the confounding influence of these factors serves to disambiguate the correlates of digital engagement from other factors on the basis of the existing literature.^{13,16,17} Child-level variables included age and sex, White or people of color, presence of major life stressors, social support, and general health. Family-level variables included whether or not caregivers had completed secondary school, family adjustment, whether the family was able to get by financially, whether the family could afford food, and whether they received government assistance. Finally, community-level variables comprised neighborhood conditions, and included measures of the presence of "vandalism such as broken windows or graffiti," affordances for outdoor activities such as "a recreation center, community center, or boys' and girls' club" and "a park or playground," as well as social cohesion indicators such as "people in this neighborhood help each other out", and social support: "When we encounter difficulties, we know where to go for help in our community." The full list

of control variables are detailed in the study's preregistration materials.²⁴

RESULTS

Preliminary Analyses

Zero-order Pearson product-moment correlations (Table 2) indicated that TV-based ($r = -0.19, p < .001$) and device-based ($r = -0.16, p < .001$) were negatively associated with psychosocial functioning. Ancillary analyses furthermore highlighted that the child-, caregiver-, and household-level control variables were significantly associated with daily digital engagement and psychosocial functioning in 38 of the 39 observed pairwise comparisons. This pattern of correlations underlined the empirical value of adjusting for the variability linked to the control variables in hypothesis testing as detailed in the analysis plan.

Confirmatory Analyses

In line with the preregistered data analysis plan,²⁸ 2 multiple regression models were used to test the correlates of TV- and device-based digital screen engagement. In the first step, the control variables detailed above were included in the models, and, in subsequent steps, both linear and nonlinear (ie, parabolic) estimates of digital screen engagement were entered as predictors. Whether the linear and parabolic relations with digital screen engagement accounted for significant shares of variance in psychosocial functioning was of special interest in this model testing procedure (Table 3). If the parabolic terms were significant, our analysis plan specified calculating the local extrema (the inflection point at which the slope switches sign) to determine what constituted moderate engagement. Our plan specified splitting the data at this value to evaluate two additional regression tests. These tests examined the linear relationships linking digital engagement to children's and young people's psychosocial functioning at either side of these inflection points (Table 4). Three deviations from the previously preregistered analysis plan merit mention. First, the sample size ($n = 35,718$) was smaller than expected ($n = 55,000$ and $77,000$) because the scope of the 2016 NSCH was reduced, as data collection now happens on an annual basis. Second, although it does not change the significance, direction, or standardized magnitude of correlations under scrutiny, we standardized our criterion variable for psychosocial functioning to provide a consistent unit for comparing across confirmatory, exploratory, and sensitivity analyses. Finally, we included an additional control variable reflecting the mental health of the primary caregiver as a result of feedback received during the peer review process. Findings were virtually identical in terms of both effect size and significance with and without this control.

Results from the TV-based digital engagement models (Table 3, top) provided evidence that the association in question had both linear ($B = -0.077$; 95% CI = -0.086 to -0.083) and parabolic components ($B = -0.040$; 95% CI = -0.033 to -0.207) components. Analysis indicated that the local maximum, the "Goldilocks level," was 1 hour 3 minutes (Table 4). The data were split at this local extremum. Results show significant but small positive associations below the extremum (using TV lower) ($B = 0.061$; 95% CI = 0.023 to 0.098). There was a negative trend in evidence when examining the data above the extremum (using TV more than the optimum amount) ($B = -0.137$ (95% CI = -0.156 to -0.118)).

Results from the device-based digital engagement models (Table 3, top), provided evidence that the association also consisted of linear ($B = -0.072$; 95% CI = -0.086 to -0.068) and parabolic ($B = -0.041$; 95% CI = -0.048 to -0.034) components. The Goldilocks level for device-based digital engagement was at 1 hour 19 minutes (Table 4). Using this optimum to bifurcate the data, we found significant but small positive associations below the extremum ($B = 0.132$; 95% CI = 0.091 to 0.173), and a negative trend above the extremum ($B = -0.130$; 95% CI = -0.146 to -0.114).

Exploratory Analyses

We conducted a series of exploratory tests to estimate the level of digital engagement necessary for caregivers to be able to subjectively sense a difference in their child's psychosocial functioning. Results from analyses focusing on TV-based digital engagement indicated that every hour of engagement past the maximum (ie, 1 hour 3 minutes) was associated with -0.137 SDs of drop in psychosocial functioning, as judged by caregivers. Using the $SD = 0.50$ MID standard, we found that a child would need to engage 4 hours 41 minutes (1 hour 3 minutes + 3 hours 38 minutes) of TV-based activities on a daily basis for caregivers to notice a difference in their child's psychosocial functioning.

Results examining digital device-based engagement indicated that every hour of engagement past the maximum (ie, 1 hour 19 minutes) was associated with a -0.13 -SD drop in psychosocial functioning. Following the calculations used for TV-based engagement, we found that children would require at least 5 hours 8 minutes of device-based engagement every day before caregivers could notice a difference in their child's psychosocial functioning.

Expressed differently, these analyses suggested that a young person would have to be ≥ 2.8 SDs above the average for TV-based engagement, or 2.7 SDs above the

TABLE 2 Observed Zero-Order Correlations Between Observed Variables

Variable	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.
1. Child age	—													
2. Sex (female)	0.007	—												
3. Parent education	-0.010	0.003	—											
4. Family adjustment	-0.100***	0.005	0.024***	—										
5. People of color	-0.035***	0.011*	-0.084***	0.002	—									
6. Hard getting by	0.010	-0.006	-0.050***	-0.149***	0.031***	—								
7. Affording food	-0.011*	-0.007	-0.079***	-0.130***	0.077***	0.600***	—							
8. Neighborhood affordance	-0.013*	-0.004	0.069***	0.069***	0.056***	-0.169***	-0.167***	—						
9. Major life stressors	0.095***	0.016***	-0.047***	-0.135***	0.069***	0.315***	0.281***	-0.097***	—					
10. Child's general health	-0.052***	0.012*	0.097***	0.175***	-0.071***	-0.239***	-0.228***	0.096***	-0.200***	—				
11. Social support	0.019***	0.027***	0.077***	0.088***	-0.106***	-0.080***	-0.088***	0.047***	-0.035***	0.087***	—			
12. Neighborhood cohesion	-0.006	-0.010	0.086***	0.260***	-0.137***	-0.324***	-0.323***	0.220***	-0.206***	0.234***	0.230***	—		
13. TV-based engagement	0.118***	-0.112***	-0.045***	-0.117***	0.049***	0.152***	0.140***	-0.072***	0.121***	-0.140***	-0.071***	-0.130***	—	
14. Device-based engagement	0.437***	0.004	-0.027***	-0.165***	0.049***	0.125***	0.111***	-0.040***	0.147***	-0.124***	-0.063***	-0.117***	0.485***	—
15. Psychosocial functioning	-0.016***	0.125***	0.044***	0.287***	-0.012*	-0.261***	-0.228***	0.121***	-0.289***	0.385***	0.101***	0.268***	-0.192***	-0.163***

Note: *p < .05, ***p < .001.

TABLE 3 Results of Models Linking Psychosocial Functioning to Daily Digital Screen Engagement With Adjustments for the Control Variables

Predictor	Type of effect	β	SE	95% CI	β	p
TV-based engagement	Linear	-0.077	0.004	[-0.086, -0.083]	-0.083	<.001
	Quadratic	-0.040	0.004	[-0.047, -0.033]	-0.181	<.001
Device-based engagement	Linear	-0.072	0.004	[-0.086, -0.068]	-0.087	<.001
	Quadratic	-0.041	0.003	[-0.048, -0.034]	-0.222	<.001

Note: Linear and parabolic relations were tested while controlling for variability linked to control variables. SE = standard error; TV = television.

average for device-based use, before a caregiver would be able to sense any significant differences in psychosocial functioning.

Sensitivity Analyses

A final series of analyses was conducted to test the robustness of the results reported above, using a more recent dataset drawn from the latest round of the NSCH. The methodology of the 2017 NSCH was nearly identical to the 2016 methodology, except that the sample size was smaller (n = 21,533). Measures of psychosocial functioning (mean = 2.76, SD = 0.33, α = 0.78), TV-based engagement (mean = 1 hour 30 minutes, SD = 1 hour 6 minutes) and device-based engagement (mean = 1 hour 32 minutes, SD = 1hour 16 minutes) were the equivalent in both waves.

The pattern of correlations and regression models broadly mirrored those generated from our preregistered analyses of the 2016 NSCH, with the exception of the correlations associated with TV-based digital engagement. Both linear (B = -0.081; 95% CI = -0.094 to -0.068) and parabolic (B = -0.023; 95% CI = -0.034 to -0.013) trends were in evidence as expected, but both the trends below (B = -0.054; 95% CI = -0.076 to -0.031) and above (B = -0.145; 95%

CI = -0.219 to -0.071) the local maximum were negative. These results did not support the Goldilocks hypothesis for TV-based screen time in the 2017 data. In place of an increase, an extremely small negative trend turned more negative after 2 hours 11 minutes of daily engagement. The average child would need to spend 6 hours 10 minutes engaging with TV-based activities on a daily basis for caregivers to notice a lower level of psychosocial functioning in their child.

As expected, there were both linear (B = -0.078; 95% CI = -0.091 to -0.066) and parabolic (B = -0.046; 95% CI = -0.056 to -0.036) links relating device-based digital engagement to psychosocial functioning. The local maximum for device-based digital engagement in the 2017 NSCH dataset (1 hour 20 minutes) was 1 minute higher compared to the extremum derived from the 2016 NSCH data. Using this value to bifurcate the data, we found a significant but small positive association below the extremum (B = 0.149; 95% CI = 0.089-0.209) and negative association above the extremum (B = -0.138; 95% CI = -0.162 to -0.115). Furthermore, analyses indicated that children would have to use digital devices for at least 4 hours 57 minutes each day before caregivers would be expected to notice a difference in their child’s psychosocial functioning.

TABLE 4 Trends in Psychosocial Functioning for Engagement Levels Below and Above the Observed Extrema

Predictor and engagement level	Extremum	B	SE	95% CI	β	p
TV-based engagement	1 h 2 min					
Below extremum		0.061	0.019	[0.023-0.098]	0.022	.001
Above extremum		-0.138	0.010	[-0.157 to -0.119]	-0.104	<.001
Device-based Engagement	1 h 19 min					
Below extremum		0.133	0.021	[0.174, 0.060]	0.047	<.001
Above extremum		-0.131	0.008	[-0.115 to -0.184]	-0.104	<.001

Note: Linear relations were tested while controlling for variability linked to control variables. SE = standard error.

DISCUSSION

As digital devices are playing an increasingly large role in childhood and adolescence, research probing the relations between screen-based technologies and children's wellness is critically needed. The present work aimed to investigate whether and at what levels digital engagement relates to lower levels of psychosocial functioning. Guided by pressing policy and clinical demands, the existing literature,^{16,17} and an approach grounded in open science,²⁹ the results provide evidence for a number of outstanding questions concerning excessive digital technology engagement.

In line with previous research findings, parabolic relations between digital screen engagement and psychosocial functioning were in evidence in 3 of 4 instances tested. In both preregistered analyses, the associations linking TV- and device-based digital engagement to psychosocial outcomes could be described as parabolic, with individuals having levels of engagement at 1 hour 3 minutes and 1 hour 19 minutes showing higher levels of psychosocial functioning compared to nonusers. Children who used digital devices for less time showed a positive relationship between their digital engagement and psychosocial functioning; however, the opposite trend was clear if they used digital devices in greater amounts. Because both the positive and negative correlates of digital engagement were very small in terms of standardized effect sizes, there needs to be an empirical frame to judge at what point these associations would be related to practically important differences in psychosocial functioning.

To address this, we performed exploratory analyses to answer the question of how much time, over and above moderate engagement, does a young person have to engage with screens before an association with psychosocial difficulties could be detected by a caregiver? Given that such judgements are inherently subjective, it was determined that a minimum effect size, grounded in research on human experience, was needed.^{20,21} We used an empirically-derived threshold and found that an average young person would need to engage with TV- and device-based screen activities for about 5 hours a day before a parent would be able to discern differences in functioning. This is not to say that the association was significant in clinical terms. For this to be the case, the association would have to be substantially larger than the MID ($d > 1.5$) before a media researcher could be justified in drawing such an inference.³⁰ Instead, the data analyzed here suggest an empirical basis for identifying excessive use might, estimating it to be about 3 SDs above the population mean.

This is a noteworthy finding, given that these estimates are well outside of the measured range of digital engagement in the NHSC dataset. In other words, the levels of digital engagement that we estimated were necessary to observe a subjectively detectable difference in psychosocial functioning were well above the 0- to 4-hour range that caregivers were provided to rate their child's digital engagement. This suggests that very few children, if any, routinely use TV- and device-based screens enough, on average, to be understood to present meaningfully lower levels of psychosocial functioning. Instead, these findings indicate that other dimensions of digital engagement, including the content of and caregiver engagement with screens, provide more promising accounts of psychosocial functioning.³¹ These results speak to the larger literature concerned with the potential effects of digital screen time on young people and suggest that statistical significance, where accompanied by study preregistration, provides necessary but insufficient evidence for determining whether digital screens have a practically significant association with the health and well-being of young people.¹⁸

Those drafting guidance for caregivers, educators, and health professionals should be informed by these findings. Albeit small, the positive correlations linking moderate digital engagement, between 1 and 2 hours a day, and psychosocial functioning is evident both in this study and in 2 earlier investigations of young people aged 6 months to 17 years in the United Kingdom and the United States.^{16,17} These associations speak to the idea that digital engagement, depending on how it is measured, does not necessarily displace positive developmental experiences such as face-to-face socializing.¹⁸ Furthermore, the UNCRC is clear that young people have a right to play and information, if rich analogue opportunities fail in providing this, digital contexts can be an invaluable avenue for access.^{32,33} When viewed in this light, calls for blanket technology bans and age-based restrictions on technology access do not constitute evidence-based or indeed ethical advice when understood through a wider human rights framework.^{4,8} Applying the MID²¹ as a SESOI and using these data as a guide, our results suggest the briefest, empirically defensible, time-based limit would be ≥ 5 hours a day of screen-based engagement. We would caution against instituting this as a limit, however, as the nature of the data under analysis cannot rule out plausible reverse causality.

Those studying the impacts of media on users should also find the results and approach of this study useful. Although the literature examining the correlates of technology engagement is largely exploratory and non-transparent,^{34,35} this work represents one of a growing

number of preregistered and transparent investigations into digital media use and its association with diverse outcomes including aggression,³⁶ sleep quality and duration,³⁷ psychological well-being,¹⁶ and behavioral dysregulation.³⁸

In terms of empirical robustness, this study provides a new and stringent baseline for scholarship investigating the health correlates of technology use.³⁹ Given that the reported influence and impact of digital devices are inherently subjective, the present research suggests that the MID SESOI should be the default for judging whether an association between digital engagement and pediatric outcomes are subjectively, but not clinically, significant. Researchers deviating from this minimum value should make their scientific and policy rationale for anchoring results to other thresholds explicit, while additionally conducting power analyses prior to data collection to ensure that their work is sensitive to such thresholds.

The present study should be carefully considered in light of a number of limitations that, if addressed in future research, can further improve our understanding of digital engagement effects. First, the data under analysis were collected as part of a large-scale annual cohort study; as such, conclusions must be made with care because they were based on cross-sectional and correlational data, which have been shown to be weaker than those emerging from experimental methods in technology use.⁴⁰ There are reasonable alternative explanations, such as a third factor (eg, parenting style) responsible for both detriments to psychosocial functioning and higher screen time, but these possibilities would *reduce* the identified effect size rather than increase it. Furthermore, the current design did not allow within-person longitudinal trends in digital engagement and psychosocial functioning to be examined. Because the NSCH is conducted on an annual basis, it provides an opportunity to test whether patterns observed herein replicate over time, as we did with our sensitivity analyses, but it cannot speak to the longer-term longitudinal impacts of technology use. Future research should focus on similar high-quality data from experience sampling and longitudinal datasets.

Second, both the explanatory and outcome variables analyzed in this work were single-source data provided by caregivers at one time point. Such data are vulnerable to response bias (eg, because a parent's concern leads her or him to consider both screen time and psychosocial functioning as exaggerated, or alternatively because a parent wants to be viewed favorably and so reports both limited screen use and higher child psychosocial functioning). It is therefore possible that estimates would be lower, or, less likely but possible, higher, if such single-source data bias were eliminated in future studies.⁴¹

Future research should therefore endeavor to use convergent self-reports from multiple respondents (children, caregivers, teachers, nurses) over time to rule out reverse causality, and should integrate device- or platform-level trace data to build a fuller picture of the relations at play. To these ends, new collaborative data initiatives such as the Adolescent Brain Cognitive Development study⁴² provide the best near-term resources for scientists interested in the longer-term impacts of digital engagement on pediatric outcomes. Finally, the present study focused entirely on the quantity, not quality, of two different types of digital screen engagement. Those coordinating cohort studies, such as the NSCH, should include data regarding the structure, features, and content of varied media.

Given the ubiquity of digital devices, the idea that their use relates to lower psychosocial functioning of children and young people is a concerning one. Because of the high professional stakes for clinicians and scientists making claims about the positive and negative implications of digital engagement, studies examining their relations with wellness and functioning must investigate the most pressing policy questions while being grounded in transparent scientific practices. This study presents one such attempt, complementing confirmatory hypothesis-testing models with exploratory and sensitivity analyses. The use of open materials, open code for restructuring and analyzing publicly available data, and clearly defined preregistered hypotheses greatly informs the existing literature, which has been predominantly exploratory. Although data rely on a large but cross-sectional dataset, by building on this strong and transparent foundation, the study's findings speak to a rapidly developing area of research. The body of research suggests that the relations between digital screen time and health outcomes are parabolic and that the negative correlates of excessive screen time are subjectively experienced only after very long periods of daily digital engagement. Digital screen time is only one of many challenges presented by modern digital childhood, and it remains to be determined whether it is a useful topic for research councils, scientists, and clinicians to devote time, attention, and research resources.

Accepted August 1, 2019.

Drs. Przybylski and Orben are with the University of Oxford, United Kingdom. Dr. Przybylski is also with the Oxford Internet Institute, University of Oxford, United Kingdom. Dr. Orben is also with Emmanuel College and Medical Research Council Cognition and Brain Sciences Unit, University of Cambridge, United Kingdom. Dr. Weinstein is with the School of Psychology, Cardiff University, United Kingdom.

No funding was secured for this study. Drs. Przybylski and Orben are supported by a grant from Barnardo's UK. Dr. Przybylski is supported by an Economic and Social Research Council Understanding Society Policy Fellowship Grant ES/K005146/1 and a grant from the Huo Family Foundation. Dr. Orben

was supported by a European Union Horizon 2020 IBSEN Grant. These funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Drs. Przybylski, Orben, and Weinstein served as the statistical experts for this research.

Disclosure: Drs. Przybylski, Orben, and Weinstein have reported no biomedical financial interests or potential conflicts of interest.

Correspondence to Andrew K. Przybylski, PhD, Oxford Internet Institute, 1 St. Giles' Oxford, Oxfordshire, OX1 3JS, UK; e-mail: andy.przybylski@oii.ox.ac.uk

0890-8567/\$36.00/©2019 American Academy of Child and Adolescent Psychiatry. Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

<https://doi.org/10.1016/j.jaac.2019.06.017>

REFERENCES

- How Teens and Parents Navigate Screen Time and Device Distractions | Pew Research Center. August 2018; <http://www.pewinternet.org/2018/08/22/how-teens-and-parents-navigate-screen-time-and-device-distractions/>. Accessed November 28, 2018.
- Internet use and attitudes. *Metrics Bull.* 2017;2017:22.
- Impact of social media and screen-use on young people's health inquiry launched—News from Parliament. UK Parliament; <https://www.parliament.uk/business/committees/committees-a-z/commons-select/science-and-technology-committee/news-parliament-2017/social-media-young-peoples-health-inquiry-launch-17-19/>. Accessed November 28, 2018.
- Council on Communications and Media. Media use by children younger than 2 years. *Pediatrics.* 2011;128:1040-1045.
- Ferguson CJ. Everything in moderation: moderate use of screens unassociated with child behavior problems. *Psychiatr Q.* 2017;88:797-805.
- Brown A, Shiffrin DL, Hill DL. Beyond 'turn it off': how to advise families on media use. *AAP News.* 2015;36: 54-54.
- Houghton S, Hunter SC, Rosenberg M, *et al.* Virtually impossible: limiting Australian children and adolescents daily screen based media use. *BMC Public Health.* 2015;15:5.
- Council on Communications and Media. Media and young minds. *Pediatrics.* 2016;138:e20162591-e20162591.
- Choi J, Cho H, Lee S, Kim J, Park E-C. Effect of the online game shutdown policy on internet use, Internet addiction, and sleeping hours in Korean adolescents. *J Adolesc Health.* 2018;62:548-555.
- Carson V, Hunter S, Kuzik N, *et al.* Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab.* 2016;41 (6 (Suppl 3):S240-S265.
- Costigan SA, Barnett L, Plotnikoff RC, Lubans DR. The health indicators associated with screen-based sedentary behavior among adolescent girls: a systematic review. *J Adolesc Health.* 2013;52:382-392.
- Nathanson AI, Aladé F, Sharp ML, Rasmussen EE, Christy K. The relation between television exposure and executive function among preschoolers. *Dev Psychol.* 2014;50:1497-1506.
- Parkes A, Sweeting H, Wight D, Henderson M. Do television and electronic games predict children's psychosocial adjustment? Longitudinal research using the UK Millennium Cohort Study. *Arch Dis Child.* 2013;98:341-348.
- Ferguson CJ, Donnellan MB. Is the association between children's baby video viewing and poor language development robust? A reanalysis of Zimmerman, Christakis, and Meltzoff (2007). *Dev Psychol.* 2014;50:129-137.
- Schmidt ME, Rich M, Rifas-Shiman SL, Oken E, Taveras EM. Television viewing in infancy and child cognition at 3 years of age in a US cohort. *Pediatrics.* 2009;123:e370-e375.
- Przybylski AK, Weinstein N. A large-scale test of the Goldilocks hypothesis: quantifying the relations between digital-screen use and the mental well-being of adolescents. *Psychol Sci.* 2017;28:204-215.
- Przybylski AK, Weinstein N. Digital Screen Time Limits and Young Children's Psychological Well-Being: Evidence From a Population-Based Study. *Child Dev.* 2019; 90(1):e56-e65.
- Orben A, Przybylski AK. The association between adolescent well-being and digital technology use. *Nat Hum Behav.* 2019;3:173-182.
- Ellis DA, Davidson BI, Shaw H, Geyer K. Do smartphone usage scales predict behaviour? *In J Hum-Comput St.* 2019;130:86-92.
- Miller GA. The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychol Rev.* 1956;63:81-97.
- Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality of life: the remarkable universality of half a standard deviation. *Med Care.* 2003;41: 582-592.
- Orben A, Przybylski AK. Screens, teens, and psychological well-being: evidence from three time-use-diary studies. *Psychol Sci.* 2019. <https://doi.org/10.1177/0956797619830329>.
- Health Resources & Services Administration. National Survey of Children's Health. 2017. Available at: <https://mchb.hrsa.gov/data/national-surveys>.
- Przybylski AK, Orben A, Weinstein N. Code for restructuring and analysis. 2019; <https://osf.io/2xr95/>. Accessed July 28, 2020.
- Goodman R, Ford T, Simmons H, Gatward R, Meltzer H. Using the Strengths and Difficulties Questionnaire (SDQ) to screen for child psychiatric disorders in a community sample. *Br J Psychiatry J Ment Sci.* 2000;177:534-539.
- Matsuishi T, Nagano M, Araki Y, *et al.* Scale properties of the Japanese version of the Strengths and Difficulties Questionnaire (SDQ): a study of infant and school children in community samples. *Brain Dev.* 2008;30:410-415.
- Becker A, Hagenberg N, Roessner V, Woerner W, Rothenberger A. Evaluation of the self-reported SDQ in a clinical setting: do self-reports tell us more than ratings by adult informants? *Eur Child Adolesc Psychiatry.* 2004;13(Suppl 2):II17-II24.
- Przybylski AK, Orben A, Weinstein N. Analysis plan. <https://osf.io/v8brp/>. Accessed July 28, 2020.
- Munafò MR, Nosek BA, Bishop DVM, *et al.* A manifesto for reproducibility science. *Nat Hum Behav.* 2017;1:0021.
- Gervais RO, Ben-Porath YS, Wygant DB, Sellbom M. Incremental validity of the MMPI-2-RF over-reporting scales and RBS in assessing the veracity of memory complaints. *Arch Clin Neuropsychol.* 2010;25:274-284.
- Livingstone S, Helsper EJ. Parental mediation of children's Internet use. *J Broadcast Electron Media.* 2008;52:581-599.
- Livingstone S, Bulger ME. A global agenda for children's rights in the digital age. Recommendations for developing UNICEF's research strategy. *LSEUNICEF Off Res.* 2013.
- United Nations Assembly. Convention on the rights of the child Vol 1577.
- Elson M, Ferguson CJ. Twenty-five years of research on violence in digital games and aggression: empirical evidence, perspectives, and a debate gone astray. *Eur Psychol.* 2013; 19:33-46.
- Elson M, Przybylski AK. The science of technology and human behavior: standards, old and new. *J Media Psychol.* 2017;29:1-7.
- McCarthy RJ, Coley SL, Wagner MF, Zengel B, Basham A. Does playing video games with violent content temporarily increase aggressive inclinations? A pre-registered experimental study. *J Exp Soc Psychol.* 2016;67:13-19.
- Przybylski AK. Digital screen time and pediatric sleep: evidence from a preregistered cohort study. *J Pediatr.* 2019;205:218-223.e1.
- Weinstein N, Przybylski AK, Murayama K. A prospective study of the motivational and health dynamics of Internet gaming disorder. *Peer J.* 2017;5:e3838.
- Ferguson CJ. An effect size primer: a guide for clinicians and researchers. *Prof Psychol Res Pract.* 2009;40:532-538.
- Ferguson CJ. Evidence for publication bias in video game violence effects literature: a meta-analytic review. *Aggress Violent Behav.* 2007;12:470-482.
- Cronbach LJ, Meehl PE. Construct validity in psychological tests. *Psychol Bull.* 1955;52: 281-302.
- Volkow ND, Koob GF, Croyle RT, *et al.* The conception of the ABCD study: from substance use to a broad NIH collaboration. *Dev Cogn Neurosci.* 2018;32:4-7.