Research Article

Psychological Science
2017, Vol. 28(2) 204–215


Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/0956797616678438
www.psychologicalscience.org/PS

# A Large-Scale Test of the Goldilocks Hypothesis: Quantifying the Relations Between Digital-Screen Use and the Mental Well-Being of Adolescents

**Andrew K. Przybylski[1,2] and Netta Weinstein[3]**
[1]Oxford Internet Institute, University of Oxford; [2]Department of Experimental Psychology, University of Oxford; and [3]School of Psychology, Cardiff University

## Abstract
Although the time adolescents spend with digital technologies has sparked widespread concerns that their use might be negatively associated with mental well-being, these potential deleterious influences have not been rigorously studied. Using a preregistered plan for analyzing data collected from a representative sample of English adolescents ($n$ = 120,115), we obtained evidence that the links between digital-screen time and mental well-being are described by quadratic functions. Further, our results showed that these links vary as a function of when digital technologies are used (i.e., weekday vs. weekend), suggesting that a full understanding of the impact of these recreational activities will require examining their functionality among other daily pursuits. Overall, the evidence indicated that moderate use of digital technology is not intrinsically harmful and may be advantageous in a connected world. The findings inform recommendations for limiting adolescents' technology use and provide a template for conducting rigorous investigations into the relations between digital technology and children's and adolescents' health.

## Keywords
screen time, digital technology, adolescents, mental well-being, open data, open materials, preregistered

Received 6/29/16; Revision accepted 10/19/16

The proliferation of digital devices has fundamentally changed how humans work, play, and socialize. Rapid technological developments in high-speed Internet, flat-panel displays, and mobile computing power have led to devices that now define and shape modern childhood (Lenhart, Smith, Anderson, Duggan, & Perrin, 2015). For example, the amount of time adolescents spend online has more than doubled from an average of 8 hr per week in 2005 to 18.9 hr per week today (Ofcom, 2015), and the time spent with these technologies, especially during childhood and adolescence, has sparked concerns that their use might be negatively associated with mental and social well-being (for a review of this controversy, see Bell, Bishop, & Przybylski, 2015). Indeed, the American Academy of Pediatrics has recommended that restrictions be placed on children's screen time (Council on Communications and Media, 2013), indicating that there are incremental costs of screen time for children's wellness, though the value of this limitation-focused approach has been questioned by developmental (Linebarger & Vaala, 2010) and clinical (Ferguson & Donnellan, 2014) researchers.

The goal of the present research was to evaluate different ways of understanding how screen time is linked to mental well-being, and to empirically quantify and define moderate engagement in digital activities. To date, one view of the effects of screen time predominates the literature: the *displacement hypothesis* (Neuman, 1988), which posits that the harms of technology are directly proportional to exposure. Effects are claimed to be negative because digital activities supplant alternate activities such as socializing with peers and family, reading books, or exercising. We tested an alternate theory, implicit in

**Corresponding Author:**
Andrew K. Przybylski, Oxford Internet Institute, Department of Experimental Psychology, University of Oxford, Oxford, United Kingdom OX1 3JS
E-mail: andy.przybylski@oii.ox.ac.uk

the literature but not explicitly studied, which we label the *digital Goldilocks hypothesis*. According to this hypothesis, tech use at moderate levels is not intrinsically harmful (Etchells, Gage, Rutherford, & Munafò, 2016; Parkes, Sweeting, Wight, & Henderson, 2013; Przybylski, 2014) and may be advantageous in a connected world, whereas "overuse" may indeed displace alternate activities, for example, interfering with school or with extracurricular or other social activities (Valkenburg & Peter, 2009). In the fairy tale, Goldilocks identifies moderation (in porridge and beds) as "just right." Similarly, it might be that "too little" tech use deprives young people of important social information and peer pursuits, whereas "too much" may displace other meaningful activities. Our Goldilocks hypothesis postulates that there are empirically derivable balance points, moderate levels, that are "just right" for optimally connected young people.

To the extent that digital activities either enrich adolescents or displace more rewarding activities, they should have, respectively, positive or negative effects on adolescents' mental well-being, which we define as flourishing characterized by positive emotions, effective functioning (including psychosocial functioning), and a sense of life satisfaction (Ryan & Deci, 2000; Tennant et al., 2007). According to the displacement hypothesis, the relationship between screen time and well-being is negative and monotonic, as each "dose" of screen time takes the place of alternative pursuits that might be more satisfying. However, recent research suggests that this account may not accurately describe the role of digital technology in everyday life. Indeed, adolescents must develop their identity and build life and social skills, and doing so fosters well-being (Luyckx, Soenens, Goossens, Beckx, & Wouters, 2008; Yarcheski, Mahon, & Yarcheski, 2001). It may be that technology provides opportunities to pursue these developmental challenges in a satisfying way. For example, although many people may think of gaming as a socially isolating activity, research indicates that online gaming handles are one of the first pieces of information that 38% of adolescent boys share when they meet someone with whom they would like to be friends (Lenhart et al., 2015). Similarly, 83% of adolescents say that social media makes them feel more connected to their friends, and 68% say that they have received social support using digital technologies in tough or challenging times (Lenhart et al., 2015). Thus, there is good reason to think that digital engagement, in moderation, may not be disruptive, and that it may even support development.

Much of what is known regarding the possible influence of screen time comes from the study of sedentary and nonsedentary activity in young people. Guided by the displacement hypothesis, existing research has compared activities by looking at physical health correlates such as body mass index (Anderson, Economos, & Must, 2008; Boone, Gordon-Larsen, Adair, & Popkin, 2007), amount of rigorous exercise (Anderson et al., 2008; Sisson, Broyles, Baker, & Katzmarzyk, 2010), or energy expenditure (Lanningham-Foster et al., 2006). Definitions and operationalizations of what constitutes engagement in an activity vary, but most studies have tested how doses of activities of interest relate to physical and psychological outcomes. Nearly all have found statistically significant differences between sedentary and nonsedentary activities, identifying the former as deleterious, but patterns evident in the literature hint at a richer dynamic than the displacement account suggests.

First, these studies have documented only weak links between screen time and health, which suggests the possibility of a stronger alternative theoretical account (Anderson et al., 2008; Boone et al., 2007; Iannotti, Kogan, Janssen, & Boyce, 2009). Second, research indicates that any detrimental effects of screen time on physical health depend on the type of digital activity, and that some screen activities actually promote physical activity (Lanningham-Foster et al., 2006). Third, studies examining physical outcomes (Anderson et al., 2008; Boone et al., 2007; Sisson et al., 2010), and preliminary work examining psychological ones, have shown inconsistent linear relations (Kremer et al., 2014), or used post hoc bucketed predictors, and estimated effects for comparable types of digital technologies vary widely (Cao et al., 2011; Hamer, Stamatakis, & Mishra, 2009, 2010). A handful of recent large-scale studies indicate that low to moderate levels (i.e., < 2–3 hr per day) of playing video games (Etchells et al., 2016; Przybylski, 2014) and watching films (Parkes et al., 2013) have little or no relation to emotional and social functioning, and that such activities may have negative effects for young people only at higher levels of engagement.

The research reported here was the first to systematically test for curvilinear relations between well-being and screen time measured continuously, separately for different digital activities and days of the week. As predicted by the Goldilocks hypothesis, we expected to find curvilinear associations, with no costs to mental well-being for moderate levels of screen time and some detriments at high levels. For the first time in this area of research, we defined low and high levels of screen time empirically by testing for local maxima, the inflection points, operationalized as the points at which the slopes relating screen time to well-being approached zero before reversing in sign. Thus, we identified the point at which each type of media use shifted from having a null or positive relation with mental well-being to having a negative relation indicating a detrimental effect.

## Method

### Participants

Participants were identified using the United Kingdom's Department for Education National Pupil Database. Fieldwork covered a total of 150 local authorities across England, with the aim of making sufficient observations of English 15-year-olds to attain a ±0.3% margin of error at a 95% confidence interval. A notification letter sent to parents or caregivers of potential participants gave them the opportunity to opt their child out of the survey, and written consent was collected directly from all participants. The original sampling frame for the study included 298,080 15-year-olds. Of these, 2,835 were lost because the surveys were undeliverable or adolescent participants opted out of the study prior to data collection. A total of 120,115 participants provided usable data by responding to paper ($n$ = 100,850) or online ($n$ = 19,265) questionnaires.

### Ethical review

A comprehensive ethical review regarding the data collection was conducted by the United Kingdom's National Children's Bureau, and an ethics review regarding the data analysis was conducted by the research ethics committee at the University of Oxford.

### Measures

***Criterion variable: mental well-being.*** The Warwick-Edinburgh Mental Well-Being Scale (Tennant et al., 2007), a 14-item self-report instrument validated for use in general population samples of individuals ages 13 years and above, was used to measure the happiness, life satisfaction, psychological functioning, and social functioning of participants. As found in past research using this instrument with young people (Stewart-Brown et al., 2009), the scale showed high internal consistency (Cronbach's $\alpha$ = .90). Scores ranged from 14 to 70 ($M$ = 47.52, $SD$ = 9.55).

***Explanatory variables: digital-screen time.*** Participants were asked four questions regarding their engagement in different kinds of digital activities during their free time. Specifically, they were asked about watching films and other media (e.g., TV programs), playing games (e.g., on computers and consoles), using computers (e.g., Internet, e-mail), and using smartphones (e.g., social networking, chatting online).

***Control and confounding variables.*** Past research has linked both the explanatory and the criterion variables to gender and ethnicity (Clarke et al., 2011) and economic factors (Eynon & Helsper, 2015; Tennant et al., 2007). These were treated as control variables for the purposes of statistical modeling. Self-reported gender on the survey was coded 1 for male and 0 otherwise. Aggregate information derived from postal-code data was used to identify if participants lived in a relatively deprived local-authority district (Department for Communities and Local Government, 2015). Residence in an area in the upper two quintiles of the multiple deprivation index (i.e., an area with high scores on unemployment, crime, poor public services, and barriers to housing) was coded 1; residence in an area in the lower two quintiles was coded 0. Minority status was assessed on the survey by asking participants about their ethnic background; they were instructed that ethnic identification can be based on many things, such as skin color, culture, language, or family ancestry. Following the approach taken by the United Kingdom Office for National Statistics (2012), we assigned 0 as the code for participants who self-identified as White and 1 as the code for those who reported being of other ethnicities.

## Results

### Analytic strategy

The preregistered analytic strategy is available at the Open Science Framework (osf.io/b4cgq). There were three deviations from that plan. First, two control variables we intended to include in the statistical models were not available: (a) whether participants' parents were married and (b) whether participants were born in the United Kingdom. Second, it was clear from the plotted data (see Fig. 1) that there were no negative monotonic relationships between digital-screen time and mental well-being. A negative linear trend could technically be fit onto the data, but its suitability would be poor, as outcome values increased across levels of the explanatory variables before decreasing. Therefore, our regression models considered trends with both linear and quadratic components. Finally, when we examined the distributions of total digital-screen time, the sums of the estimates, it was clear that many participants had reported simultaneous screen use; approximately 20% of the sample reported a sum of more than 12 hr of engagement on weekdays, and 35% of the sample reported a total of more than 12 hr on weekend days. Given that these values were consistent with earlier research demonstrating that digital media are often used in parallel (Eynon & Helsper, 2015), it did not make theoretical or practical sense to follow the original plan to test these summed screen-time estimates.

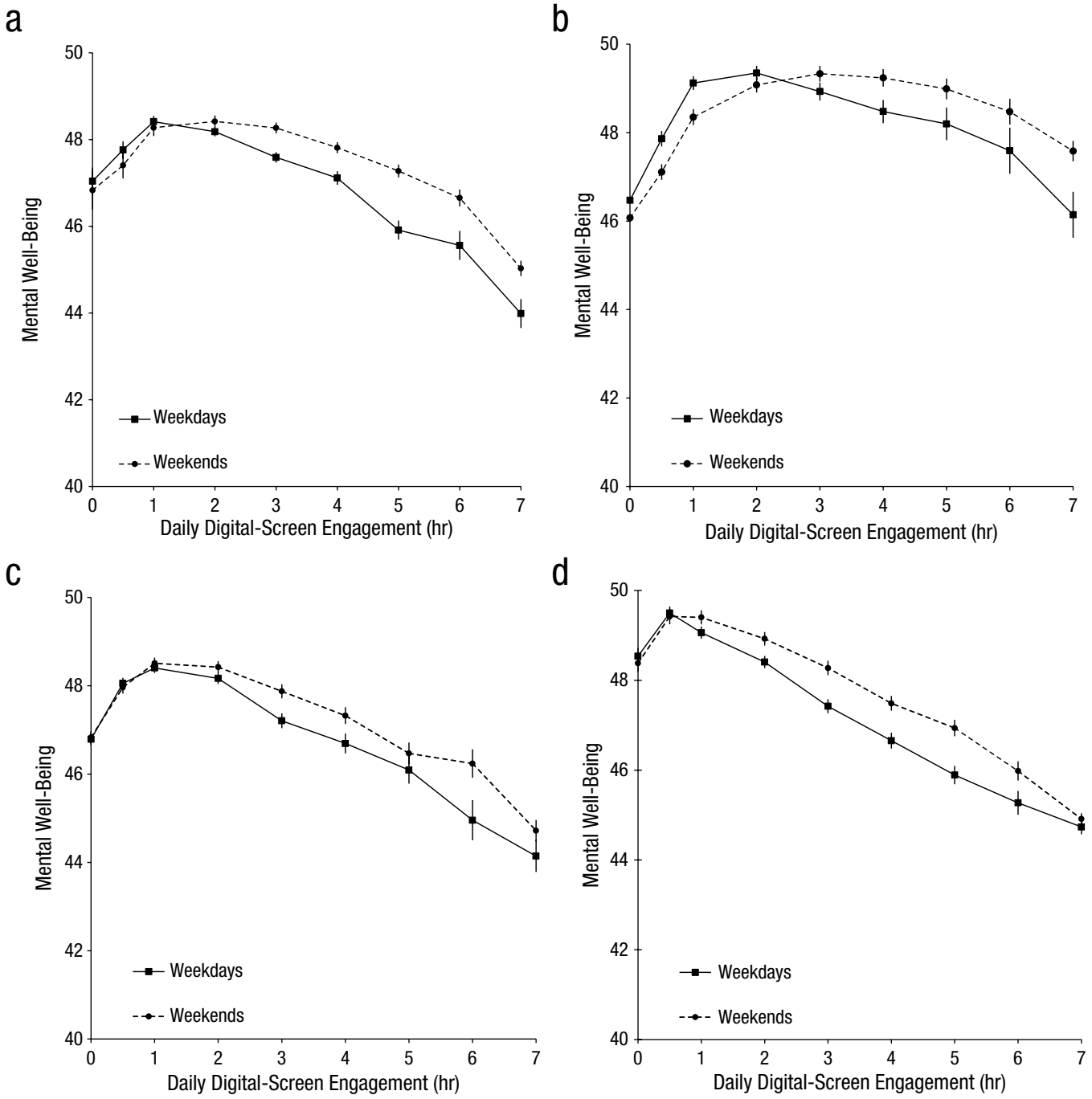


**Fig. 1.** Mental well-being as a function of daily digital-screen time on weekdays and weekends. Results are shown separately for time spent (a) watching TV and movies, (b) playing video games, (c) using computers, and (d) using smartphones. Error bars denote the 95% confidence intervals for the observed means.

## *Exploratory analyses*

Engagement in digital activities was quite popular in our sample, as more than 99.9% of the participants reported allocating some time to at least one form of digital technology on a daily basis. Exploratory *t* tests comparing boys' and girls' responses indicated that the girls reported spending more time using smartphones, using computers, and watching videos, and the boys devoted more time to playing computer and console games (all *p*s < .001; Fig. 2). Across the four types of activities, screen time was between 25 min and 1 hr 5 min longer on

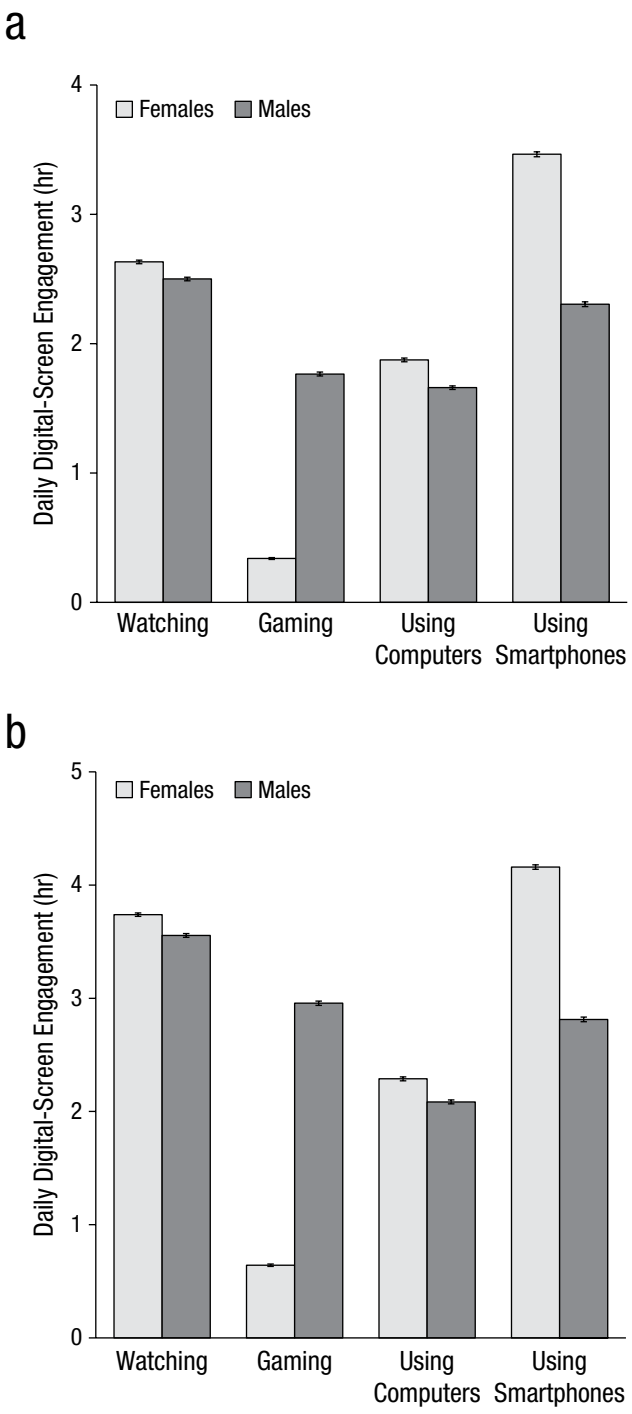


**Fig. 2.** Daily digital-screen time on (a) weekdays and (b) weekend days, separately for male and female participants. Error bars denote the 95% confidence intervals for the observed means.

weekend days than on weekdays, and paired-samples *t* tests showed that these differences were significant, all *p*s < .001. Repeated measures analyses of variance using within-subjects contrasts indicated that more time was spent using smartphones than engaging in the other three categories of screen-based activities, all *p*s < .001 (Fig. 2). Note that boys devoted far more time to gaming on both weekdays and weekend days compared with girls.

## *Confirmatory analyses*

A series of regression models tested how weekday and weekend engagement with digital screens was related to mental well-being, assessed with the Warwick-Edinburgh Mental Well-Being Scale. These analyses, which included both linear and nonlinear components, indicated that the quadratic trends evident in Figure 1 were statistically significant for all four types of digital activities. Concave-down quadratic functions were evident for watching films and TV on weekdays and weekends, for playing games on weekdays and weekends, for using a computer on weekdays and weekends, and for using a smartphone on weekdays (see Table 1 for the results of the regression models). Consistency across both weekdays and weekends and across four different types of digital activities provided support for the Goldilocks hypothesis. In sum, a direct comparison of the relation between screen time and mental well-being at low versus high levels of screen time—a comparison that, to our knowledge, has not been made in previous work—revealed that this relation does in fact vary with the level of screen time. When we treated gender, economic factors and technology access, and ethnicity as control variables in the models, half of the observed effect sizes were noticeably reduced, but the direction and significance of the effects were unchanged (Table 2).

***Empirically derived inflection points.*** To further define the quadratic patterns present in the data, we calculated local extrema for the models statistically controlling for variance linked to potential confounds. If indeed the relations between mental well-being and digital-screen time are nonlinear, systematically quantifying the point at which engagement shifts from benign to harmful is important (Nelson & Simonsohn, 2014). Results from these analyses revealed clear inflection points relating screen time to well-being (Table 3, Fig. 3). Local extrema were at 1 hr 40 min for weekday video-game play and 1 hr 57 min for weekday smartphone use. In contrast, watching videos and using computers for recreational purposes appeared to be less potentially disruptive at these levels, as the local extrema for these activities on weekdays were 3 hr 41 min and 4 hr 17 min, respectively. Indeed, some digital activities might be better suited than others to weekdays. For example, it is relatively easy to switch between different tasks using a computer, whereas an activity such as playing a video game requires more dedicated attention. For weekends, the derived inflection

**Table 1.** Results of Models Linking Mental Well-Being to Daily Digital-Screen Engagement Without Adjustments for the Control Variables

| Time of week and type of effect | *b* | *SE* | 95% CI | *p* | \|*d*\| |
|---|---|---|---|---|---|
| Watching films, TV programs, etc. | | | | | |
| Weekday | | | | | |
| Linear | 0.98 | 0.10 | [0.79, 1.17] | < .001 | 0.06 |
| Quadratic | –0.14 | 0.01 | [–0.16, –0.12] | < .001 | 0.09 |
| Weekend | | | | | |
| Linear | 1.53 | 0.09 | [1.36, 1.71] | < .001 | 0.10 |
| Quadratic | –0.17 | 0.01 | [–0.18, –0.15] | < .001 | 0.13 |
| Playing games | | | | | |
| Weekday | | | | | |
| Linear | 3.56 | 0.11 | [3.34, 3.77] | < .001 | 0.19 |
| Quadratic | –0.33 | 0.01 | [–0.35, –0.31] | < .001 | 0.17 |
| Weekend | | | | | |
| Linear | 3.16 | 0.08 | [3.00, 3.32] | < .001 | 0.22 |
| Quadratic | –0.26 | 0.01 | [–0.28, –0.25] | < .001 | 0.20 |
| Using computers for Internet, e-mail, etc. | | | | | |
| Weekday | | | | | |
| Linear | 1.32 | 0.09 | [1.13, 1.50] | < .001 | 0.08 |
| Quadratic | –0.17 | 0.01 | [–0.18, –0.15] | < .001 | 0.11 |
| Weekend | | | | | |
| Linear | 1.61 | 0.08 | [1.45, 1.78] | < .001 | 0.11 |
| Quadratic | –0.18 | 0.01 | [–0.19, –0.16] | < .001 | 0.14 |
| Using smartphones for social networking, chatting, etc. | | | | | |
| Weekday | | | | | |
| Linear | –0.50 | 0.08 | [–0.65, –0.35] | < .001 | 0.04 |
| Quadratic | –0.02 | 0.01 | [–0.03, –0.01] | .019 | 0.01 |
| Weekend | | | | | |
| Linear | 0.50 | 0.08 | [0.35, 0.65] | < .001 | 0.04 |
| Quadratic | –0.10 | 0.01 | [–0.11, –0.09] | < .001 | 0.09 |

Note: Quadratic relations were tested while controlling for linear relations. CI = confidence interval.

points ranged from 3 hr 35 min for playing video games to 4 hr 50 m for watching videos. Thus, the pivot points between moderate and potentially harmful screen time were notably higher and less variable for weekend days than for weekdays, which suggests that the nature and amount of engagement matter for understanding the relations between digital-screen time and mental well-being.

Below these thresholds, the relations between screen time and mental well-being were either positive ($p \leq .001$) or flat ($ps > .183$), except for a negative link in the case of weekend smartphone use (Fig. 3, Table 3). Above these thresholds, the consistent negative monotonic relationships for all forms of digital-screen time ($bs \leq -0.53$, $ps < .001$, $|d|s = 0.14–0.20$) indicated a detrimental relation between screen time and mental well-being. These findings further support the Goldilocks hypothesis. It appears that with the exception of using smartphones during weekends, moderate digital activity as defined by the reported inflection points does not displace other, more enriching activities essential for adolescents to experience mental well-being. Devoting time to smartphone screens during weekends may be an exception because socializing through virtual means when time is otherwise unstructured may be particularly susceptible to dysregulation or may indeed displace other beneficial weekend social activities (Ryan, Bernstein, & Brown, 2010).

***Observed effect sizes.*** Although it is not typical for publications on effects of digital activities to qualify statistically significant differences by reporting the amount of variability that is accounted for by these recreational activities, doing so is crucial for understanding the scope of the potential influence of screen time. In this study, we

**Table 2.** Results of Models Linking Mental Well-Being to Daily Digital-Screen Engagement With Adjustments for the Control Variables

| Time of week and type of effect | *b* | *SE* | 95% CI | *p* | \|*d*\| |
|---|---|---|---|---|---|
| Watching films, TV programs, etc. | | | | | |
| Weekday | | | | | |
| Linear | 0.95 | 0.09 | [0.77, 1.13] | < .001 | 0.06 |
| Quadratic | –0.13 | 0.01 | [–0.15, –0.11] | < .001 | 0.09 |
| Weekend | | | | | |
| Linear | 1.65 | 0.09 | [1.48, 1.82] | < .001 | 0.11 |
| Quadratic | –0.17 | 0.01 | [–0.19, –0.16] | < .001 | 0.13 |
| Playing games | | | | | |
| Weekday | | | | | |
| Linear | 0.21 | 0.11 | [–0.01, 0.43] | .059 | — |
| Quadratic | –0.06 | 0.01 | [–0.09, –0.04] | < .001 | 0.03 |
| Weekend | | | | | |
| Linear | 0.57 | 0.09 | [0.41, 0.74] | < .001 | 0.04 |
| Quadratic | –0.08 | 0.01 | [–0.10, –0.07] | < .001 | 0.06 |
| Using computers for Internet, e-mail, etc. | | | | | |
| Weekday | | | | | |
| Linear | 1.43 | 0.09 | [1.25, 1.61] | < .001 | 0.09 |
| Quadratic | –0.17 | 0.01 | [–0.18, –0.15] | < .001 | 0.11 |
| Weekend | | | | | |
| Linear | 1.64 | 0.08 | [1.48, 1.79] | < .001 | 0.09 |
| Quadratic | –0.18 | 0.01 | [–0.19, –0.16] | < .001 | 0.11 |
| Using smartphones for social networking, chatting, etc. | | | | | |
| Weekday | | | | | |
| Linear | 0.23 | 0.08 | [0.08, 0.38] | .003 | 0.02 |
| Quadratic | –0.06 | 0.01 | [–0.07, –0.05] | < .001 | 0.05 |
| Weekend | | | | | |
| Linear | 0.98 | 0.08 | [0.83, 1.12] | < .001 | 0.07 |
| Quadratic | –0.12 | 0.01 | [–0.13, –0.10] | < .001 | 0.10 |

Note: Quadratic relations were tested while controlling for linear relations. CI = confidence interval.

found that the average effect size (Cohen's *d*) for engagement in excess of the inflection points was –0.18. In other words, these negative slopes accounted for 1.0% or less of the observed variability in the mental well-being of the young people in the sample. Exploratory analyses examining links between individual difference measures in the data set and well-being provide some context to interpret these modest relationships. These analyses indicated that the possible negative effects of excessive screen time were less than a third of the size of the positive associations between well-being and eating breakfast regularly ($d = 0.54$) or getting regular sleep ($d = 0.58$). Although the coefficients we have reported are statistically significant, it is noteworthy that the size of both the linear and the quadratic relations between screen time and well-being were noticeably diminished in half the cases once control factors were accounted for, and that incremental increases in screen time above moderate levels accounted for very little of the variability we observed in mental well-being.

## Discussion

In this study, we found that the relationships between digital-screen time and mental well-being are nonlinear and that moderate engagement in digital activities is not harmful. The consistently observed concave-down quadratic relations and empirically derived inflection points provide evidence supporting our Goldilocks hypothesis, indicating that post hoc screen-time groupings featured in past research oversimplify the nature of the relations between digital-screen time and adolescents' well-being. We quantified moderate screen engagement and found that the categories of digital activity we examined are unlikely to

**Table 3.** Trends in Mental Well-Being for Engagement Levels Below and Above the Observed Extrema

| Time of week and engagement level | Extremum | *b* | *SE* | 95% CI | *p* | \|*d*\| |
|---|---|---|---|---|---|---|
| Watching films, TV programs, etc. | | | | | | |
| Weekday | 3 hr 41 min | | | | | |
| Below extremum | | –0.04 | 0.03 | [–0.11, 0.02] | .183 | — |
| Above extremum | | –0.90 | 0.05 | [–1.00, –0.80] | < .001 | 0.20 |
| Weekend | 4 hr 50 min | | | | | |
| Below extremum | | 0.09 | 0.03 | [0.04, 0.15] | .001 | 0.02 |
| Above extremum | | –1.09 | 0.06 | [–1.20, –0.98] | < .001 | 0.20 |
| Playing games | | | | | | |
| Weekday | 1 hr 40 min | | | | | |
| Below extremum | | 0.00 | 0.09 | [–0.18, 0.18] | .984 | — |
| Above extremum | | –0.60 | 0.04 | [–0.67, –0.53] | < .001 | 0.19 |
| Weekend | 3 hr 35 min | | | | | |
| Below extremum | | –0.02 | 0.03 | [–0.09, –0.05] | .519 | — |
| Above extremum | | –0.63 | 0.05 | [–0.72, –0.53] | < .001 | 0.17 |
| Using computers for Internet, e-mail, etc. | | | | | | |
| Weekday | 4 hr 17 min | | | | | |
| Below extremum | | 0.01 | 0.02 | [–0.04, 0.06] | .665 | — |
| Above extremum | | –0.89 | 0.11 | [–1.11, –0.67] | < .001 | 0.15 |
| Weekend | 4 hr 39 min | | | | | |
| Below extremum | | 0.15 | 0.02 | [0.10, 0.19] | < .001 | 0.04 |
| Above extremum | | –0.93 | 0.08 | [–1.09, –0.77] | < .001 | 0.16 |
| Using smartphones for social networking, chatting, etc. | | | | | | |
| Weekday | 1 hr 57 min | | | | | |
| Below extremum | | 0.80 | 0.11 | [0.58, 1.01] | < .001 | 0.07 |
| Above extremum | | –0.53 | 0.02 | [–0.56, –0.49] | < .001 | 0.20 |
| Weekend | 4 hr 10 min | | | | | |
| Below extremum | | –0.10 | 0.02 | [–0.15, –0.05] | < .001 | 0.03 |
| Above extremum | | –0.83 | 0.06 | [–0.94, –0.74] | < .001 | 0.14 |

Note: The predictors for engagement levels below the extrema included engagement at the extrema. Quadratic relations were tested while controlling for linear relations. CI = confidence interval.

present a material risk to mental well-being at these moderate levels, although high levels of engagement may have a measurable, albeit small, negative influence. These findings are all firsts, perhaps because previous studies used omnibus measures that did not differentiate between the diverse types of digital-screen use (Sisson et al., 2010) and measured doses of screen time on the basis of arbitrary cutoffs (Hamer et al., 2009). Such approaches are limited because they discard informative variance and therefore pool nonharmful and potentially harmful amounts of engagement when effects are estimated.

This study informs the field in a number of ways. We discuss two here. First, this study points to the value of considering the wider social and developmental contexts surrounding digital-screen use. The relation between screen time and well-being depended, in part, on whether the activities occurred on weekdays or weekends. The adolescents could engage in digital activities between 22 min and 2 hr 13 min longer on weekend days than on weekdays before we found evidence of negative effects. Second, we found evidence that not all digital activities are "created equal." Those that were pervasive (i.e., using smartphones) or required effortful task switching (i.e., playing video games) had noticeably lower inflection points on weekdays compared with other digital activities. It is possible that some tech activities do interfere with other structured activities during weekdays. For example, it is likely that adolescents are less likely to engage in academic pursuits if they are overusing certain forms of media on weekdays (Junco, 2012), and it may also be the case that these adolescents are less engaged in structured after-school activities that support intrapersonal and social development, and as a result promote well-being (Fletcher, Nickerson, & Wright, 2003). Despite

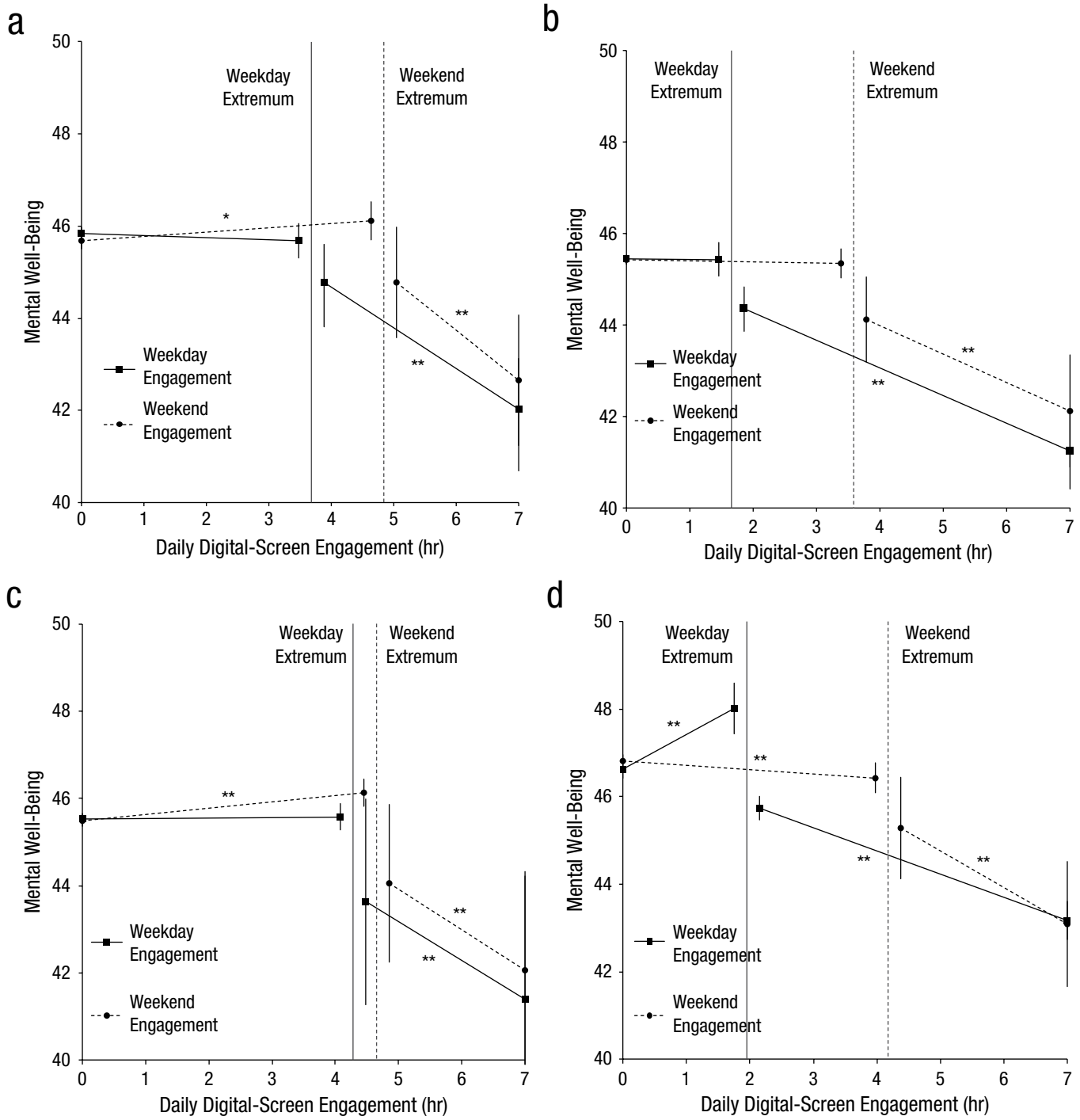


**Fig. 3.** Linear trends in the relation between daily digital-screen time and mental well-being for values of screen time falling below the local maxima and for values of screen time falling above the local maxima. Results are shown separately for time spent (a) watching TV and movies, (b) playing video games, (c) using computers, and (d) using smartphones on weekdays and on weekends. Error bars denote the 95% confidence intervals for the observed slopes. Asterisks indicate slopes significantly different from zero (*$p$ = .001, **$p$ < .001).

these possibilities, our statistical models suggested that the possible harmful influence of screen time on young people is fairly small, even if one assumes that our correlational data indicate direct causal relations.

## *Avenues for future work*

If indeed moderate engagement in digital activities has little detrimental effect on, and even some positive correlates

with, well-being, it is possible that digital technologies, when used in moderation, afford measurable advantages to adolescents. These benefits may include avenues for communication, creativity, and development (Granic, Lobel, & Engels, 2014). In future work, researchers should look more closely at how specific affordances intrinsic to digital technologies relate to benefits at various levels of engagement, while systematically analyzing what is being displaced or amplified. For example, many popular games, such as *Minecraft*, provide a context for socializing and creativity, and smartphone-based activities like geocaching provide motivation for physical activity and discovery (O'Hara, 2008). Engaging in these games and activities may not displace anything meaningful for development, whereas channel surfing and solitary reading might. Research building on these findings might examine nonlinear effects over time, and could consider effects on people both younger and older than the adolescents we sampled. Finally, future studies should use convergent data sources from caregivers, peers, and teachers to evaluate the linear and nonlinear relations between screen time and well-being. This approach would minimize the negative influence of extreme "mischievous responding" (Robinson-Cimpian, 2014), which might have exaggerated the links we observed between screen time and well-being, particularly among our respondents who reported unrealistically high levels of technology use. More important, use of other data sources would provide a further robust test of the Goldilocks hypothesis.

## *Closing remarks*

These findings highlight the need to revisit broad-stroke recommendations grounded in the displacement hypothesis (Brown, Shifrin, & Hill, 2015) and offer a new way to understand the existing research that legitimates those recommendations. Our results indicated that the possible deleterious relation between media use and well-being may not be as practically significant as some researchers have argued (Strasburger, Donnerstein, & Bushman, 2014), and they highlight the continued need to critically reevaluate research claims that go beyond the available evidence (for more on this, see Ferguson & Donnellan, 2014). Our findings also suggest the need for a careful cost-benefit analysis of existing professional advice—which at present supports allocating valuable pediatrician consultation time to discussing media use with caregivers. Future research and recommendations building on the Goldilocks hypothesis would be sensitive to the various types and contexts of media use and would be based on peaks and drops in well-being as well as other meaningful outcomes identified systematically. Paired with open-science practices, such as preregistration of statistical analyses, which limits researcher degrees of freedom (Simmons, Nelson, & Simonsohn, 2011), our analytic approach can form the basis for new robust studies in this area (Morey et al., 2016). There is good reason to think that caregivers find it extremely difficult to enforce existing guidelines regarding digital-screen time (Houghton et al., 2015), and that other factors, such as whether caregivers actively join in with their children during tech activities, may be far more important for mental well-being.

### Action Editor

Brent W. Roberts served as action editor for this article.

### Author Contributions

A. K. Przybylski developed the study concept and participated in consultations with NHS Digital regarding the data collection. Both A. K. Przybylski and N. Weinstein were responsible for the study design, data analysis, and interpretation. Both authors drafted and revised the manuscript and approved the final version for submission.

### Acknowledgments

We thank R. D. Morey and C. D. Chambers for critical feedback regarding the analysis plan. We also thank P. Glossop, P. Niblett, and members of the surveys team at NHS Digital for their support.

### Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

### Open Practices

All data and materials have been made publicly available via the Open Science Framework. The data can be accessed at osf.io/49rmq/, and the materials can be accessed at osf.io/4dv6p/. The design and analysis plans were preregistered at the Open Science Framework and can be accessed at osf.io/b4cgq. The complete Open Practices Disclosure for this article can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797616678438. This article has received badges for Open Data, Open Materials, and Preregistration. More information about the Open Practices badges can be found at https://osf.io/tvyxz/wiki/1.%20View%20the%20Badges/ and http://pss.sagepub.com/content/25/1/3.full.

### References

Anderson, S. E., Economos, C. D., & Must, A. (2008). Active play and screen time in US children aged 4 to 11 years in relation to sociodemographic and weight status characteristics: A nationally representative cross-sectional analysis. *BMC Public Health, 8*(1), Article 366. doi:10.1186/1471-2458-8-366

Bell, V., Bishop, D. V. M., & Przybylski, A. K. (2015). The debate over digital technology and young people. *British Medical Journal, 351*, Article h3064. doi:10.1136/bmj.h3064

Boone, J. E., Gordon-Larsen, P., Adair, L. S., & Popkin, B. M. (2007). Screen time and physical activity during adolescence: Longitudinal effects on obesity in young adulthood. *International Journal of Behavioral Nutrition and Physical Activity, 4*(1), Article 26. doi:10.1186/1479-5868-4-26

Brown, A., Shifrin, D. L., & Hill, D. L. (2015). Beyond "turn it off": How to advise families on media use. *AAP News, 36*(10), 54. doi:10.1542/aapnews.20153610-54

Cao, H., Qian, Q., Weng, T., Yuan, C., Sun, Y., Wang, H., & Tao, F. (2011). Screen time, physical activity and mental health among urban adolescents in China. *Preventive Medicine, 53*, 316–320. doi:10.1016/j.ypmed.2011.09.002

Clarke, A., Friede, T., Putz, R., Ashdown, J., Martin, S., Blake, A., . . . Stewart-Brown, S. (2011). Warwick-Edinburgh Mental Well-Being Scale (WEMWBS): Validated for teenage school students in England and Scotland. A mixed methods assessment. *BMC Public Health, 11*, Article 487. doi:10.1186/1471-2458-11-487

Council on Communications and Media. (2013). Children, adolescents, and the media. *Pediatrics, 132*, 958–961. doi:10.1542/peds.2013-2656

Department for Communities and Local Government. (2015). *The English indices of deprivation 2015*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/465791/English_Indices_of_Deprivation_2015_-_Statistical_Release.pdf

Etchells, P. J., Gage, S. H., Rutherford, A. D., & Munafò, M. R. (2016). Prospective investigation of video game use in children and subsequent conduct disorder and depression using data from the Avon Longitudinal Study of Parents and Children. *PLoS ONE, 11*(1), Article e0147732. doi:10.1371/journal.pone.0147732

Eynon, R., & Helsper, E. (2015). Family dynamics and Internet use in Britain: What role do children play in adults' engagement with the Internet? *Information, Communication & Society, 18*, 156–171. doi:10.1080/1369118X.2014.942344

Ferguson, C. J., & Donnellan, M. B. (2014). Is the association between children's baby video viewing and poor language development robust? A reanalysis of Zimmerman, Christakis, and Meltzoff (2007). *Developmental Psychology, 50*, 129–137. doi:10.1037/a0033628

Fletcher, A. C., Nickerson, P., & Wright, K. L. (2003). Structured leisure activities in middle childhood: Links to well-being. *Journal of Community Psychology, 31*, 641–659. doi:10.1002/jcop.10075

Granic, I., Lobel, A., & Engels, R. C. M. E. (2014). The benefits of playing video games. *American Psychologist, 69*, 66–78. doi:10.1037/a0034857

Hamer, M., Stamatakis, E., & Mishra, G. (2009). Psychological distress, television viewing, and physical activity in children aged 4 to 12 years. *Pediatrics, 123*, 1263–1268. doi:10.1542/peds.2008-1523

Hamer, M., Stamatakis, E., & Mishra, G. D. (2010). Television- and screen-based activity and mental well-being in adults. *American Journal of Preventive Medicine, 38*, 375–380. doi:10.1016/j.amepre.2009.12.030

Houghton, S., Hunter, S. C., Rosenberg, M., Wood, L., Zadow, C., Martin, K., & Shilton, T. (2015). Virtually impossible: Limiting Australian children and adolescents daily screen based media use. *BMC Public Health, 15*, Article 5. doi:10.1186/1471-2458-15-5

Iannotti, R. J., Kogan, M. D., Janssen, I., & Boyce, W. F. (2009). Patterns of adolescent physical activity, screen-based media use, and positive and negative health indicators in the U.S. and Canada. *Journal of Adolescent Health, 44*, 493–499. doi:10.1016/j.jadohealth.2008.10.142

Junco, R. (2012). The relationship between frequency of Facebook use, participation in Facebook activities, and student engagement. *Computers & Education, 58*, 162–171. doi:10.1016/j.compedu.2011.08.004

Kremer, P., Elshaug, C., Leslie, E., Toumbourou, J. W., Patton, G. C., & Williams, J. (2014). Physical activity, leisure-time screen use and depression among children and young adolescents. *Journal of Science and Medicine in Sport, 17*, 183–187. doi:10.1016/j.jsams.2013.03.012

Lanningham-Foster, L., Jensen, T. B., Foster, R. C., Redmond, A. B., Walker, B. A., Heinz, D., & Levine, J. A. (2006). Energy expenditure of sedentary screen time compared with active screen time for children. *Pediatrics, 118*, e1831–e1835. doi:10.1542/peds.2006-1087

Lenhart, A., Smith, A., Anderson, M., Duggan, M., & Perrin, A. (2015). *Teens, technology and friendships*. Retrieved from http://www.pewinternet.org/2015/08/06/teens-technology-and-friendships/

Linebarger, D. L., & Vaala, S. E. (2010). Screen media and language development in infants and toddlers: An ecological perspective. *Developmental Review, 30*, 176–202. doi:10.1016/j.dr.2010.03.006

Luyckx, K., Soenens, B., Goossens, L., Beckx, K., & Wouters, S. (2008). Identity exploration and commitment in late adolescence: Correlates of perfectionism and mediating mechanisms on the pathway to well-being. *Journal of Social & Clinical Psychology, 27*, 336–361. doi:10.1521/jscp.2008.27.4.336

Morey, R. D., Chambers, C. D., Etchells, P. J., Harris, C. R., Hoekstra, R., Lakens, D., . . . Zwaan, R. A. (2016). The Peer Reviewers' Openness Initiative: Incentivizing open research practices through peer review. *Royal Society Open Science, 3*(1), Article 150547. doi:10.1098/rsos.150547

Nelson, L. D., & Simonsohn, U. (2014, September 17). *Thirty-somethings are shrinking and other U-shaped challenges*. Retrieved from http://datacolada.org/27

Neuman, S. B. (1988). The displacement effect: Assessing the relation between television viewing and reading performance. *Reading Research Quarterly, 23*, 414–440. doi:10.2307/747641

Ofcom. (2015). *Children and parents: Media use and attitudes report 2015*. Retrieved from http://stakeholders.ofcom.org.uk/market-data-research/other/research-publications/childrens/children-parents-nov-15/

Office for National Statistics. (2012). *Ethnicity and national identity in England and Wales: 2011*. Retrieved from http://www.ons.gov.uk/peoplepopulationandcommunity/culturalidentity/ethnicity/articles/ethnicityandnationalidentityinenglandandwales/2012-12-11/pdf

O'Hara, K. (2008). Understanding geocaching practices and motivations. In *CHI '08: Proceedings of the SIGCHI Conference*

*on Human Factors in Computing Systems* (pp. 1177–1186). New York, NY: ACM Press. doi:10.1145/1357054.1357239

Parkes, A., Sweeting, H., Wight, D., & Henderson, M. (2013). Do television and electronic games predict children's psychosocial adjustment? Longitudinal research using the UK Millennium Cohort Study. *Archives of Disease in Childhood, 98*, 341–348. doi:10.1136/archdischild-2011-301508

Przybylski, A. K. (2014). Electronic gaming and psychosocial adjustment. *Pediatrics, 134*, e716–e722. doi:10.1542/peds.2013-4021

Robinson-Cimpian, J. P. (2014). Inaccurate estimation of disparities due to mischievous responders: Several suggestions to assess conclusions. *Educational Researcher, 43*, 171–185. doi:10.3102/0013189X14534297

Ryan, R. M., Bernstein, J. H., & Brown, K. W. (2010). Weekends, work, and well-being: Psychological need satisfactions and day of the week effects on mood, vitality, and physical symptoms. *Journal of Social & Clinical Psychology, 29*, 95–122. doi:10.1521/jscp.2010.29.1.95

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*, 68–78. doi:10.1037/0003-066X.55.1.68

Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-positive psychology: Undisclosed flexibility in data collection and analysis allows presenting anything as significant. *Psychological Science, 22*, 1359–1366. doi:10.1177/0956797611417632

Sisson, S. B., Broyles, S. T., Baker, B. L., & Katzmarzyk, P. T. (2010). Screen time, physical activity, and overweight in U.S. youth: National Survey of Children's Health 2003. *Journal of Adolescent Health, 47*, 309–311. doi:10.1016/j.jadohealth.2010.02.016

Stewart-Brown, S., Tennant, A., Tennant, R., Platt, S., Parkinson, J., & Weich, S. (2009). Internal construct validity of the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS): A Rasch analysis using data from the Scottish Health Education Population Survey. *Health and Quality of Life Outcomes, 7*, Article 15. doi:10.1186/1477-7525-7-15

Strasburger, V. C., Donnerstein, E., & Bushman, B. J. (2014). Why is it so hard to believe that media influence children and adolescents? *Pediatrics, 133*, 571–573. doi:10.1542/peds.2013-2334

Tennant, R., Hiller, L., Fishwick, R., Platt, S., Joseph, S., Weich, S., . . . Stewart-Brown, S. (2007). The Warwick-Edinburgh Mental Well-Being Scale (WEMWBS): Development and UK validation. *Health and Quality of Life Outcomes, 5*, Article 63. doi:10.1186/1477-7525-5-63

Valkenburg, P. M., & Peter, J. (2009). Social consequences of the Internet for adolescents: A decade of research. *Current Directions in Psychological Science, 18*, 1–5. doi:10.1111/j.1467-8721.2009.01595.x

Yarcheski, A., Mahon, N. E., & Yarcheski, T. J. (2001). Social support and well-being in early adolescents: The role of mediating variables. *Clinical Nursing Research, 10*, 163–181.