Technology and children's screen-based activities in the UK:

The story of the millennium so far

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Abstract

Much has changed over recent years in the technology that children use in their daily lives. The impact of these changes on children's time in screen-based activities has been the source of much debate and concern. Yet we know very little about change in children's daily time in screen-based activities, including their time using devices such as smartphones and tablets. Using data from two nationally representative UK Time Use Surveys 2000-01 and 2014-15, this paper presents a detailed study of change in children's (8-18 years) daily time in screen-based activities (TV, videogames, and computers), together with the latest data on their time using computers and mobile devices throughout the day. We find that children's screen-based activities increased by around half an hour between 2000 and 2015, but that this was concentrated among boys who increased their time playing videogames. Dwarfing this, however, was the additional time children spent using computers and mobile devices when engaging in other activities throughout the day, especially for girls. Multivariate analysis of factors associated with children's screen-based activities revealed that gender differences in children's time playing videogames widened significantly over this period, while socio-economic differences in children's screen-based activities remained fixed. This study highlights how children are combining old and new technologies in their daily lives, and points to issues for future developments in the measurement of children's engagement in screen-based activities, that are critical for properly assessing the impact of technology on children's well-being.

Keywords: change in screen-based activities; children and technology; gender; digital divide; time use data

Introduction

Rapid technological change from the turn of the millennium, especially with the development of devices such as smartphones and tablets, has led to renewed concerns about the time children spend in screen-based activities. The number of screen-based devices children now use has multiplied and, with improvements in internet connections and enhanced functionality of these devices, children now use them in a variety of different ways for a variety of different purposes. Public and academic debate and concern often centres on the amount of time children are now spending in screen-based activities, with the proposition that this has increased to worryingly high levels. Screen-based activities are sedentary in nature, and they draw our attention away from face-to-face interactions with others. Excessive time

in screen-based activities may therefore have a detrimental impact on aspects of children's health and well-being. Yet we are lacking reliable indicators of the daily time children spend in screen-based activities, how this has changed, and indicators of their daily time using new devices such as smartphones and tablets. Addressing this using data from two nationally representative UK Time Use Surveys 2000-01 and 2014-15, this paper tracks changes in, and factors associated with, the time children 8-18 years spend in screen-based activities (TV, computers, and videogames), and analyses new indicators of children's time using devices such as smartphones and tablets throughout the day.

Background

The first fifteen years of the new millennium have witnessed a dramatic expansion in children's access to and use of technology and the internet. At the turn of the millennium, 44% of households in the UK owned a computer, and 32% were connected to the internet (ONS 2002); although, families with children were more likely to own a computer in the early 2000s (Holloway and Valentine 2003: 27). By 2005, around two thirds of children 8-15 years had access to the internet at home, rising to around 95% in 2015 (Ofcom 2015). At the end of the first decade of the new millennium smartphones were still relatively novel, and the *iPad* tablet had just been released on the market, but children very quickly took possession of, and began using, these devices. Smartphone ownership among children 8-11 years rose from 13% to 24% between 2010 and 2015, and from 35% to 69% for children 12-15 years over the same period (Ofcom 2015). In addition, there have been steep increases in children's access to tablet computers in the past five years. Ofcom (2015) reports that around 5% of children 5-15 years in the UK had access to tablet computer in 2010, increasing to 80% by 2015. Along with these changes, internet speeds and capacities have improved steadily, enhancing the functionality of mobile devices, and consequently children increasingly use these devices to access the internet (Livingstone et al. 2014).

The effect of increased exposure to technology and the internet on children's health and development, or well-being in general, is the subject of some debate. Some argue that technological change is one of a number of factors contributing to a supposed *toxic childhood* (Palmer 2007). Technology, it is argued, extends the range of screen-based activities children can engage in, ultimately increasing the amount of time they spend sitting in front of screens to the detriment of their physical and mental health. Certainly, there is a large body of evidence showing that excessive amounts of time in sedentary screen-based activities are negatively associated with a range of physical and mental health outcomes (for extensive reviews see: Carson et al. 2016; Tremblay et al. 2011; Suchert et al. 2015). However, as each of these reviews acknowledge, the literature is far from establishing causal links between children's screen-based activities and health outcomes, especially mental health outcomes. Furthermore, it is important to note that, in tandem with technological change, changes in other domains affecting children's daily life (e.g. in education, and to do with concerns about their safety outdoors) might well be impacting negatively on children's physical and mental health (Livingston 2016).

To obtain a better understanding of the impact of technology on children's well-being, an important prior step lies in accurately assessing the extent and nature of change in the time children spend daily in screen-based activities, over a period witnessing rapid technological change. Indeed, a striking aspect of much of the debate on children's time in screen-based

activities is the limited amount of data on how much time they actually spend daily in these activities. There is a risk here that extreme, unrepresentative, cases might come to dominate general perceptions about children's engagement in screen-based activities.

Previous empirical research has attempted to answer two questions. The first concerns the total amount of time children spend using new screen-based technology. The second relates to the composition of children's screen-based activities, and especially whether TV is ceding dominance to other newer devices and the internet. The first question is posed sometimes in relation to the amount of time children spend using devices like smartphones and tablets, and sometimes to the amount of time they spend using the internet. Though not identical, there is a substantial overlap. Ofcom (2015) reports that children 8-11 years spend around 11 hours per week and children 12-15 years spend 19 hours per week using the internet. A further Ofcom study[1] reports that children 6-15 years spend 15.5 hours per week using computers and mobile devices (excluding communication activities, but including social media), and again older children report more time using devices.[2] Children 6-11 years spend 12 hours per week using devices, while children 11-15 years spend close to 21 hours per week using these devices. On these estimates, children's time using devices is 1-2 hours greater than their time using the internet. Regardless of whether the focus is on the internet or the devices being used, children today spend a substantial amount of time using screen-based technology.

This leads to the second question relating to change in the composition of children's screen-based activities, and particularly whether TV is losing ground to newer devices and the internet. Already at the turn of the millennium children were spending substantial amounts of time using computers and playing videogames, but TV was still children's dominant screen-based activity (Livingston and Bovill 1999). However, a number of studies chart a decline in children's TV viewing together with an increase in their time using computers from the year 2000 onwards. Silva et al. (2014) found a reduction between 2001 and 2011 in the proportion of Brazilian adolescents' (15-19 years) reporting two or more hours of TV viewing, together with an increase in the proportion reporting two or more hours per day playing videogames and using computers. A study of German school-age children (11-15 years) found that TV viewing decreased between 2002 and 2010 on weekdays but not on weekends (Bucksch et al. 2014). This study also found that girls' time using computers increased over this period, on both weekdays and weekends, but they found no change for boys'. Bucksch et al. (2016) present results of a study looking at trends in TV viewing and non-gaming computer use for children 11-15 years in 30 countries. Broadly, they show that between 2002 and 2010, children's time watching TV has decreased in most countries, while their time using computers has increased.

With respect to the UK, (Scotland and Wales were the only UK countries included in the Bucksch et al. (2016) study), Ofcom (2015), reporting on children's time watching TV, using the internet, and playing videogames, suggests similar trends may be widespread across the UK. They show that between 2007 and 2015, time watching TV has decreased slightly for children 5-15 years from 15.8 hours per week to 14.8 hours per week. Over the same period,

[1] http://www.digitaldayresearch.co.uk/home/

[2] All estimates from Ofcom's *Digital Day* were obtained using http://www.digitaldayresearch.co.uk/decks/deck-creator/

weekly hours spent using the internet increased from 9.7 to 13.7, while time playing videogames increased from 7.7 hours per week to 9.7 hours per week.

The empirical research to date suggests that children spend a substantial amount of time in screen-based activities, and that there has been some change in the composition of time in screen-based activities. However, these findings are based on limited indicators derived from survey questions asking children to recall how much time they spent in different screen-based activities. For example, the measure of time watching TV in the Bucksch et al. (2016) study was based on the following question: "About how many hours a day to you usually watch TV (including DVDs and videos) in your free time?" (The question for using computers was of the same form.) These types of measures can be administered relatively quickly and cost-effectively, with minimal respondent burden. However recall-based questions are well known to provide unreliable estimates of time use (Robinson 1985; Gershuny 2000). Typically, we are not very good at accurately recalling how much time we spent in a given activity, even in the recent past. There is also the possibility that these types of measures can be affected by a social desirability bias.

A further problem with recall-based measures is that responses for different activities cannot be combined to obtain a measure of total daily time in screen-based activities. Take, for example, the Ofcom data cited above reporting that in 2015 children 5-15 years spent over the course of a week 14.8 hours watching TV, 9.7 hours playing videogames, and 13.7 hours using the internet. It is not clear whether, or to what extent, we can simply sum these to obtain a measure of total time in screen-based activities of 38.2 hours per week (5.5 hours per day). It follows that we cannot draw firm conclusions about changes in total time in screen-based activities from these data. Moreover, recall-based measures tell us nothing about the extent to which children engage in different screen-based activities at the same time, or mixing their use of screen-based devices with time in other activities. Mobile devices greatly enhance our capacity for mixing screen-based activities with other activities, facilitating multitasking or rapid task-shifting across different screen-based technologies (Turkle 2011). As we have seen, children's access to and use of these devices has increased, and consequently so has their relative importance in questions about children's time in screen-based activities. Lastly, extant research on trends in screen-based activities in the UK provides limited insight on factors associated with children's time in these activities.

Factors linked to children's screen-based activities

As well as raising questions about the overall amount of time children spend in screen-based activities and change in this, it is important to recognise that there are differences in screen-based activities between children with different characteristics. Previous research shows that boys spend more time playing videogames than girls, but that boys and girls spend similar amounts of time watching TV and using computers (Livingstone and Bovill 1999; Hofferth 2010). Children's time playing videogames increases as they enter adolescence (Livingstone and Bovill 1999; Hofferth 2010), although other studies show that playing videogames decreases as children progress through adolescence (Brooks et al. 2016; Witt et al. 2011). Time watching TV and using computers, on the other hand, is not significantly associated with age (Livingstone and Bovill 1999).

Parents exert a primary influence on their children's engagement in screen-based activities, but this varies across social groups. Studies show that parents in higher socio-economic

groups are more likely to impose restrictions on children's screen-based activities (Livingstone and Helsper 2008; Mendoza 2009; Nikken and Jansz 2014), and to orient their children towards time in other activities such as study and extra-curricular activities (Lareau 2003), which likely underpins research findings showing negative associations between mothers' education and children's time watching TV and playing videogames (Hofferth 2010).

Parents' capacities to exert control over children's time in screen-based activities may be limited by constraints on their own time (Evans et al. 2011), especially for mothers who spend most time supervising children. Mothers' paid work and whether they are a lone parent are possibly important factors in this regard. Effects of mothers' employment on children's screen-based activities are mixed however. Mullan (2010) found that children in the UK with full time employed mothers, who spent more time with their fathers, watched more TV during this time. However, research from the USA finds no association between children's time in screen-based activities and mothers' employment (Hofferth 2010; Fletcher et al. 2014). Research on the effect of lone-parent status on children's screen-based activities is restricted to studies in the USA, which find no significant association (Hofferth 2010; Fletcher et al. 2014).

This study

This study makes three contributions to research on children's time in screen-based activities and using technology. Firstly, it presents an analysis of change between 2000 and 2015 in children's time in screen-based activities (TV, computers, and videogames) using data from two UK Time Use Surveys (UKTUS) collected in 2000-01 and 2014-15. These data cover a period witnessing massive changes in the technology environment children (and adults) inhabit. Therefore, they present an unparalleled source from which to evaluate change in children's screen-based activities in the UK during this critical period. Secondly, this paper analyses factors associated with children's screen-based activities, with a particular focus on child gender and age, and socio-economic status. Thirdly, this paper analyses children's use of computers and mobile devices (smartphones and tablets) throughout the day, using new data collected in the latest survey. The full range of activities children engage in when using devices is explored and factors associated with this time are analysed. To summarise, this paper addresses the following three research questions:

1. How has children's time in screen-based activities changed between 2000 and 2015?
2. What factors are associated with children's time in screen-based activities, and have these changed between 2000 and 2015?
3. What types of non-screen based activities are children engaging in when they also report using computers and mobile devices, what factors are associated with this time in these activities?

Methodology

Data and sample

This paper uses data from the United Kingdom Time Use Surveys (UKTUS) 2000-01 and 2014-15. Both surveys obtained nationally representative samples of households and individuals in the United Kingdom using a clustered, stratified sample design. Both surveys collected information about individuals' time use, along with a range of social, economic and

demographic variables. Respondents to both surveys complete two time diaries (for a weekday and a weekend day) reporting their primary activities throughout the day, and any secondary activities they engage in. In the latest survey, respondents provided information about their use of devices (computers, smartphones, and tablets) throughout the day. Time use surveys, utilising time-diary instruments, yield reliable estimates of the time individuals spend in different activities throughout the day, providing critical insights into children's daily activities (Ben-Arieh 2002). The analysis is based on a sample of children and adolescents aged 8-18 years in full-time education and living with their parents, either in lone mother or heterosexual two-parent households (66 children living in lone-father households are excluded from the analysis). The sample contains a total of 3,434 diary days provided by 1,761 children in 2000, and 2,227 diary days provided by 1,134 children in 2015. Details of the characteristics of the sample are provided in Table 1.

Measures of screen-based activities and use of technology

Using both UKTUS 2000-01 and 2014-15, the following three measures of the time children spend in screen-based activities were created:

1. Total daily minutes watching TV as a primary or secondary activity
2. Total daily minutes playing videogames as a primary or secondary activity
3. Total daily minutes using computers as a primary or secondary activity

Note that there are six measures in total, with a primary and secondary measure for each of these three screen-based activities. Time in any of these three screen-based activities reported as a secondary activity is not counted if a screen-based activity was the primary activity. That is, for example, children's reports of watching TV as a secondary activity is not counted if their primary activity was playing videogames.[3] Lastly, in both surveys these indicators are combined to create a measure of children's total time in screen-based activities for 2000-01 and 2014-15 (reported as either a primary or secondary activity).

Then, data from UKTUS 2015 are used to measure the time children spend using devices when engaging in different activities (including the screen-based activities outlined above) throughout the day, and their total time using digital devices throughout the day. Also, using the additional information on children's use of devices, we compute a second measure of total screen-based activities in 2015. This second measure of total screen-based activities is the sum of time in primary and secondary screen-based activities, as described above, combined with children's time using devices when engaging in other activities. Note that although all devices are screen-based, it could be that they are being used to listen to music. Adjusting the measure for this, we ignore a very small amount of time using a device when children report listening to music or the radio as their primary or secondary activity.

Statistical analysis

The analysis is structured in two parts. The first part examines trends in children's screen-based activities. It begins with a descriptive overview of the average time children spend in different screen-based activities, as primary and secondary activities, and their total time in screen-based activities. In addition, this section of the analysis provides an overview of the average time children spend using digital devices for 2015 only. Following this, addressing

[3] There are few instances of this and this restriction serves to avoid any double counting.

research questions 1 and 2 directly, a multivariate regression examines whether there has been any significant change in children's screen-based activities between 2000 and 2015, and examines other factors associated with children's time in screen-based activities. The second part of the analysis, addressing research question 3, focuses on children's use of digital devices in 2015. First, there is a descriptive analysis of the average time children spend in different activities when using devices such as smartphones and tablets. Then there is a multivariate analysis of time using devices when engaging in different activities to examine factors associated with this time. All multivariate regression is estimated using OLS, which is suitable for time use data (Stewart 2013).

Independent variables

The first part of the analysis focuses on change over time in children's screen-based activities so the key independent variable is survey year, which is a binary variable identifying cases in 2015 compared with those in 2000. The models control for a number of pertinent child, parent, and household characteristics. With respect to child-level characteristics, the models include controls for child gender and age, noted above as key child-level factors associated with children's screen-based activities. With respect to parent characteristics, the model controls for mothers' education using a binary variable indicating whether or not she has a degree or higher qualification. The models also controls for whether the child's mother is in full-time or part-time paid employment, and whether the child lives in a lone-mother or two-parent (mother and father) household.

Certain resources available to children may impact upon their screen-based activities, and the model controls for whether the child lives in a household that has a computer, or a car. The absence of a computer in the home may impact negatively on children's capacities to engage in computer-based activities, which may only partly be compensated by access to computers in school or elsewhere. Computer use may be a substitute for TV at home. Therefore, children without access to a computer at home may spend more time watching TV than those with a computer at home. The lack of a family a car may impact negatively on children's capacity to engage in leisure activities outside the home.

Lastly, the models include controls for the number of children in the household and whether the diary day was a weekday or a weekend. The presence of other children in the household may increase opportunities for leisure with others thereby limiting individualised screen-based activities. Children have more time available on weekends to engage in screen-based activities, and finding alternatives to screen-based activities on weekends represents a particular challenge for parents (Evans et al. 2011). The multivariate regression in the second part of the analysis, analysing children's device use in 2015, includes the same variables as in the first part (with the exception of survey year). There is no key independent variable in this section of the analysis as the purpose here is to explore, for the first time, the correlates of children's time using devices when engaging in a range of different activities. Table 1 provides a description of the characteristics of the sample of children on these independent variables in 2000-01 and 2014-15.

Table 1. Characteristics of sample

	2000-01	2014-15
Total number of children	1,761	1,134
	%	*%*
Gender		
Boys	50.8	47.9
Girls	49.2	52.1
Age		
8-11 years	44.7	39.8
12-15 years	41.7	38.2
16-18 years	13.5	22.0
Mother's education		
No degree	83.9	67.6
Degree	11.5	30.2
Missing	4.6	2.2
Mother's employment status		
Employed full-time	27.8	31.8
Employed part-time	38.7	37.3
Not in paid work	28.8	30.9
Missing	4.8	0.0
Household structure		
Two-parent household	77.7	77.7
Lone-mother household	22.3	22.3
Home computer		
Yes	77.6	96.6
No	22.4	3.4
Access to car at home		
Yes	83.7	89.9
No	16.3	10.1
Mean number of children 0-18 years	2.4	2.3

Results

1. Changes in children's time in screen-based activities

1.1 Descriptive analysis

Table 2 shows the average time children in the UK spent in different screen-based activities in 2000 and 2015, and the average time children spent using a device (computer, smartphone, and tablet) in 2015. TV was the single most time consuming screen-based activity children engaged in, in both 2000 and 2015, but average time watching TV decreased by around 25 minutes between 2000 and 2015. However, a tripling of the average time watching TV as a secondary activity, which increased from 5 minutes to 15 minutes, has somewhat offset the decrease in primary activity TV viewing. Therefore, children's average time watching TV, either as a primary or secondary activity, decreased by only 15 minutes. Children's time using computers as a primary activity increased from 9 minutes in 2000 to 24 minutes in 2015, and their time playing videogames as a primary activity doubled from 23 minutes in 2000 to 46 minutes in 2015. There have been small increases in time when children report

these as secondary activities. Children's average time in total screen-based activities (TV, computers, and videogames), as a primary or secondary activity, increased from around 3 hours in 2000 to 3 hrs 29 minutes in 2015. Decreases in time watching TV are therefore more than offset by increases in time in other screen-based activities, leading to an increase in total screen-based primary activities over this period.

Table 2. Time in screen-based activities in 2000 and 2015, and using a device in 2015: Children 8-18 years

	Total: 2000 (hrs:mins)	**Total: 2015** (hrs:mins)	**Using device: 2015** (hrs:mins)
TV			
Primary activity	2:21	1:56	0:28
Secondary activity	0:05	0:15	0:03
Computer (internet, email etc.)			
Primary activity	0:09	0:24	0:24
Secondary activity	0:00	0:05	0:05
Videogames			
Primary activity	0:23	0:46	0:28
Secondary activity	0:00	0:02	0:01
Total (TV, computers, videogames)	2:59	3:29	1:30
Other device use (net of TV, computers, videogames)	-	-	1:16
Total + other device use	2:59	4:45	2:46

Notes: Weights applied; Device is smartphone, tablet, or computer

The estimates reported in Table 2 are similar to those reported by Ofcom (see above) for TV but not for videogames. As reported above, Ofcom estimates that children 5-15 years spent 14.8 hours per week watching TV in 2015. The estimate of average weekly hours watching TV (primary plus secondary time) derived from Table 2 was 15.1 hours[4]. The corresponding estimate for children 8-15 years was 14.5 hours. Estimates of time playing videogames on the other hand diverge substantially. Here, average weekly hours playing videogames were estimated to be 5.6 hours (6 hours for children 8-15 years), which is considerably less than Ofcom's estimate of 9.7 hours per week for children 5-15 years. As noted above, recall-based measures, as used by Ofcom, are prone to error and the results here signal a particular problem in measuring time in videogames. This might be a consequence of rapid change in the way children play videogames, with increases in time playing games on mobile devices when engaging in other activities (e.g. travel) making it harder to recall accurately total time playing videogames.

Children's time in screen-based activities, as either a primary or secondary activity, is only part of the picture in 2015, however. The last column in Table 2 reports the average time children spent using a digital device throughout the day, and shows that children 8-18 years averaged 2 hrs 46 mins using a device during the day. Note that children 8-15 years spent an average of 2hr 20 mins per day using devices (16.4 hours per week), which is relatively close to Ofcom's estimate of 15.5 hours per week for children 6-15 years, derived from a time

[4] As weights are applied, weekly estimates can be derived by multiplying daily estimates by seven.

diary instrument as part of their *Digital Day* study. The relatively small discrepancy is perhaps due to the latter including younger children 6-7 years.

Just over half of all time using a digital device (1 hrs 30 mins) overlapped with time when children reported engaging in a screen-based activity. This was split in almost equal parts across the three screen-based activities, with children reporting about half an hour using a device when watching TV, using computers, and playing videogames respectively. In relative terms, children reported using a device during about one quarter of the average time watching TV, while they reported using a device for around 60% of the average time playing videogames. Note that children can play videogames on consoles (e.g. Nintendo), therefore playing videogames need not coincide with reporting time using computers, smartphones or tablets.

For all remaining time using a device in 2015 (1 hr 16 mins), children were engaging in other activities, which will be examined in more detail below. Here, we add this time to children's total time in screen-based activities, reported as either the primary or secondary activity, to arrive at a second, broader, measure of total time in screen-based activities that includes time when children are using devices while engaging in other non-screen-based activities. The average for this measure of total time in screen-based activities for children 8-18 years in 2015 was 4 hours 45 mins per day. On this measure, children's time in screen-based activities increased by 1 hour 45 minutes between 2000 and 2015, rather than 30 minutes when we do not include additional time using devices during other activities.

1.2 Multivariate analysis of changes in children's time in screen-based activities.

The forgoing descriptive analysis shows that school-age children's time watching TV decreased while their time playing videogames and using computers increased. Multivariate regression analysis of measures of total time in each screen-based activity, as a primary or secondary activity, controlling for a number of other factors (see above), confirms that these changes were indeed statistically significant (see Table 3). Holding other factors constant, children were estimated to spend around 10 minutes less time watching TV, more time using computers (19.4 minutes), and playing videogames (29 minutes) in 2015 than in 2000. Children's total time in screen-based activities (TV, computers, videogames) increased by 38 minutes between 2000 and 2015. Note that this excludes any time using digital devices (such as smartphones or tablets) when engaging in other activities. When this time is included, total time in screen-based activities increased by 108.8 minutes between 2000 and 2015 (Table 3, final column).

Table 3. OLS results from models of children's time (minutes per day) in screen-based activities

	Watching TV	Using computers	Playing videogames	Total (TV, computers, videogames)	Total plus other device use
Survey: 2015	-10.3**	19.4***	29.0***	38.1***	108.8***
Girl	0.9	-4.9**	-46.1***	-50.1***	-40.0***
12-15 years	19.5***	10.0***	2.6	32.1***	55.9***
16-18 years	30.9***	16.7***	-14.0***	33.6***	72.7***
Mother has a degree	-15.9***	-1.5	-7.3**	-24.7***	-18.8**
Mother works FT	12.9**	-6.5**	8.0**	14.4**	14.7*
Mother Works PT	4.4	-0.8	1.8	5.4	8.2
Lone mother household	6.3	2.7	-6.8**	2.2	2.9
Household has no computer	6.0	-7.3***	-6.0*	-7.3	-5.3
Household has no car	11.5*	-1.8	14.1***	23.9***	27.7***
Number of children 0-18 years	3.1	-1.9*	-0.8	0.4	-2.8
Weekend	47.8***	3.9*	16.9***	68.5***	64.9***
Intercept	108.3***	7.5***	39.5***	155.4***	134.0***
Adjusted R-Square	0.05	0.05	0.14	0.11	0.18

Notes: N=5,446; Reference category: survey year 2000-01; boy; 8-11 years; mother does not have a degree; mother not in paid work; two-parent household; household has a computer; household has at least one car; mean number of children 0-17 years; diary day is a weekday. *** $p < .001$; ** $p < .01$; * $p < .05$

Children's time in screen-based activities varies widely according to a number of factors. Girls spent a similar amount of time watching TV to boys, but around 5 minutes less time using computers. In line with previous research a large gender difference (46 minutes) was found for children's time playing videogames. This accounts for the vast majority of the gender difference in total screen-based activities. Yet the gender gap narrowed when we included time using devices when engaging in other activities, suggesting that gender differences in screen-based activities are concentrated in time when these are the main focus of children's attention. Generally, we found a positive association between time screen-based activities and age, although there was no difference in time playing videogames between children 8-11 and 12-15, while older teenagers were found to spend significantly less time playing videogames than children 8-11 years, echoing previous research (see above).

Again confirming previous research, children 8-18 years with a mother who has a degree spent less time watching TV (-15.9 minutes), playing videogames (-7.3 minutes), and less total time in screen-based activities (-24.7 minutes), clearly dominated by the result for TV. Though not examined here, it is important to note that low-SES parents have been shown to mediate their children's screen-based activities by sharing time in these activities (e.g. by watching TV together) rather than restricting time in screen-based activities (Clark, 2014). There was no difference associated with mothers' degree status and children's time using computers.

Children 8-18 years with a full-time employed mother averaged more time watching TV (12.9 minutes), playing videogames (8 minutes). However, they averaged less time using computers (-6.5 minutes). In sum therefore, children with a full-time employed mother spend more time in total screen-based activities (14.4 minutes) than those whose mother is not in paid work. Mothers' part-time work was not significantly associated with children's time in screen-based activities. Children's time in screen-based activities was not significantly associated with family structure, with the sole exception that children in lone-mother families were estimated to spend around 7 minutes less time playing videogames.

Children in households with no computer spent less time using computers and playing videogames. This factor has less of an impact on the time children spend playing videogames, than using computers, as they can use videogames consoles for gaming (note that the coefficient for this covariate is only around 15% the size of the intercept in this model). Time in screen-based activities was higher among children in households without a car, especially time watching TV and playing videogames. This result shows clearly how material resources can influence children's daily activities.

Rounding out the multivariate results in this section, a positive association was found between the number of children 0-18 years in the household and minutes of TV viewing. Finally, children spent just over one hour more in screen-based activities on weekends than weekdays, concentrated in time watching TV.

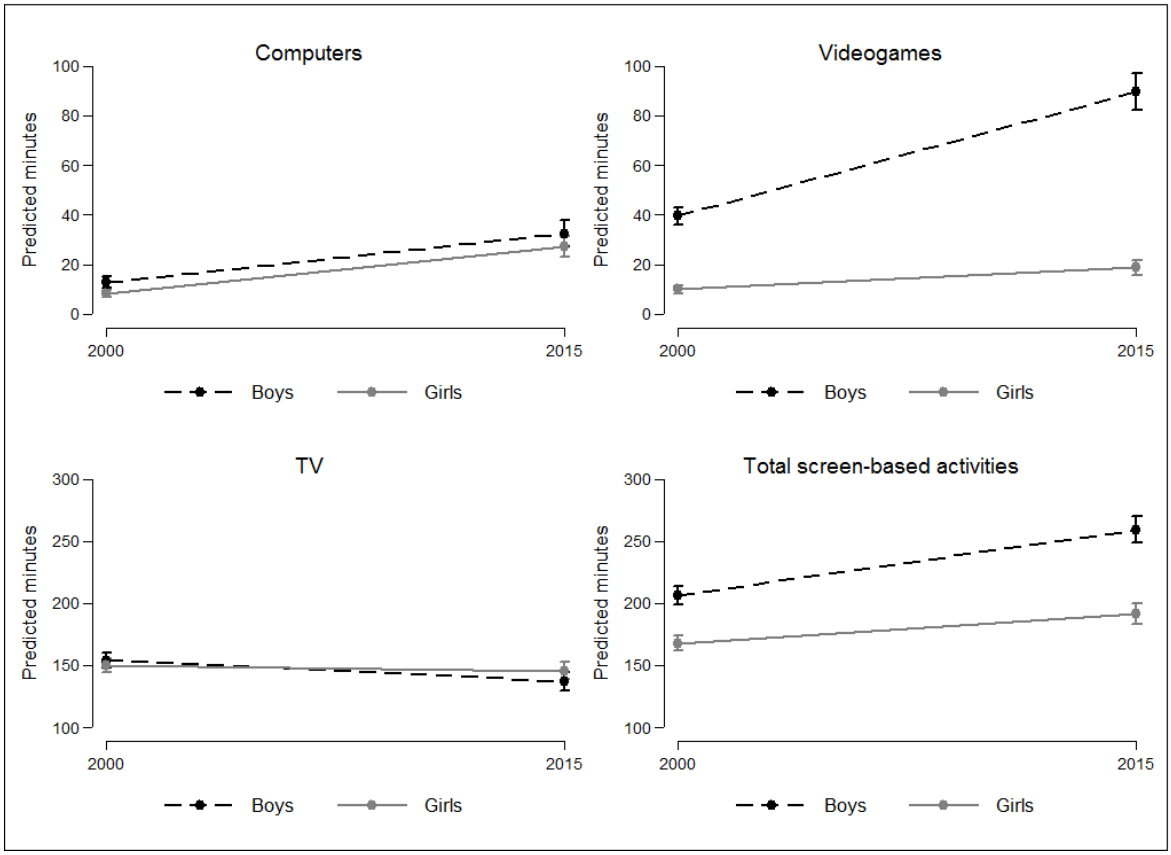
1.3 Change in factors associated with children's screen-based activities: 2000 - 2015

We turn now to consider the extent to which the influence of factors associated with children's screen-based activities has changed, or remained fixed, over time. To examine this, we tested interactions for survey year with covariates significantly associated with total screen-based activities: gender; age; mother's education; mother's employment; and

household without car. The results show remarkable stability over time in the associations with children's screen-based activities for all of these factors, with one exception. The only significant interaction between any of these factors with survey year was for gender. To examine these results, Figure 1 shows the predicted minutes from models of different screen-based activities including an interaction between survey year and gender.

There was no significant gender/survey year interaction in the models for computers and watching TV, but the increase in time playing videogames between 2000 and 2015 was significantly greater for boys than for girls (50 minutes vs. 9 minutes). Consequently, between 2000 and 2015, boys' total primary screen-based activities increased to a greater extent than girls' (53 minutes vs. 24 minutes). If other time using devices is included in the measure of total screen-based activities, this widening gender gap disappears (results not shown). This is because, as we will see in the next section, girls spend significantly more time using devices when engaging in other activities than boys.

Fig. 1 Predicted minutes from models of minutes in screen-based activities with interactions between survey year and gender



2. Other time using digital devices in 2015

In this section we turn to the third research question and examine children's time in non-screen activities when they also report using a device. We have shown above that around half of children's average time using a device is time when they are not engaging in a screen-based activity such as watching TV or playing videogames. Figure 2 shows that children use digital devices when engaging in a wide range of different activities, highlighting the extent

to which children incorporate technology into their daily lives. This includes time at school, time studying, during travel, time in leisure activities (social activities, games, and sport), time in personal activities and when eating, and time in committed activities such as housework and voluntary activities.

In absolute terms, children's average time using a device is greatest when they are at school (14 minutes), although this comprises only 7% of average total time in school. In absolute terms, children spent a similar amount of time using devices when engaging in social activities (13 minutes), and travelling (12 minutes), but which comprises almost one fifth of their average total time in these activities. Children average 9 minutes using a device when they are studying, which is close to 30% of their average time studying overall (31 minutes). Most of the remaining time children spent using a device when engaging in other activities (25 minutes) is spread relatively evenly across a diverse range of activities (personal time, games, committed time, and eating), and they spent just under 3 minutes using a device when engaging in sport and physical activity.

Fig. 2 Average time per day using digital devices when engaging in other activities in 2015: Children 8-18 years

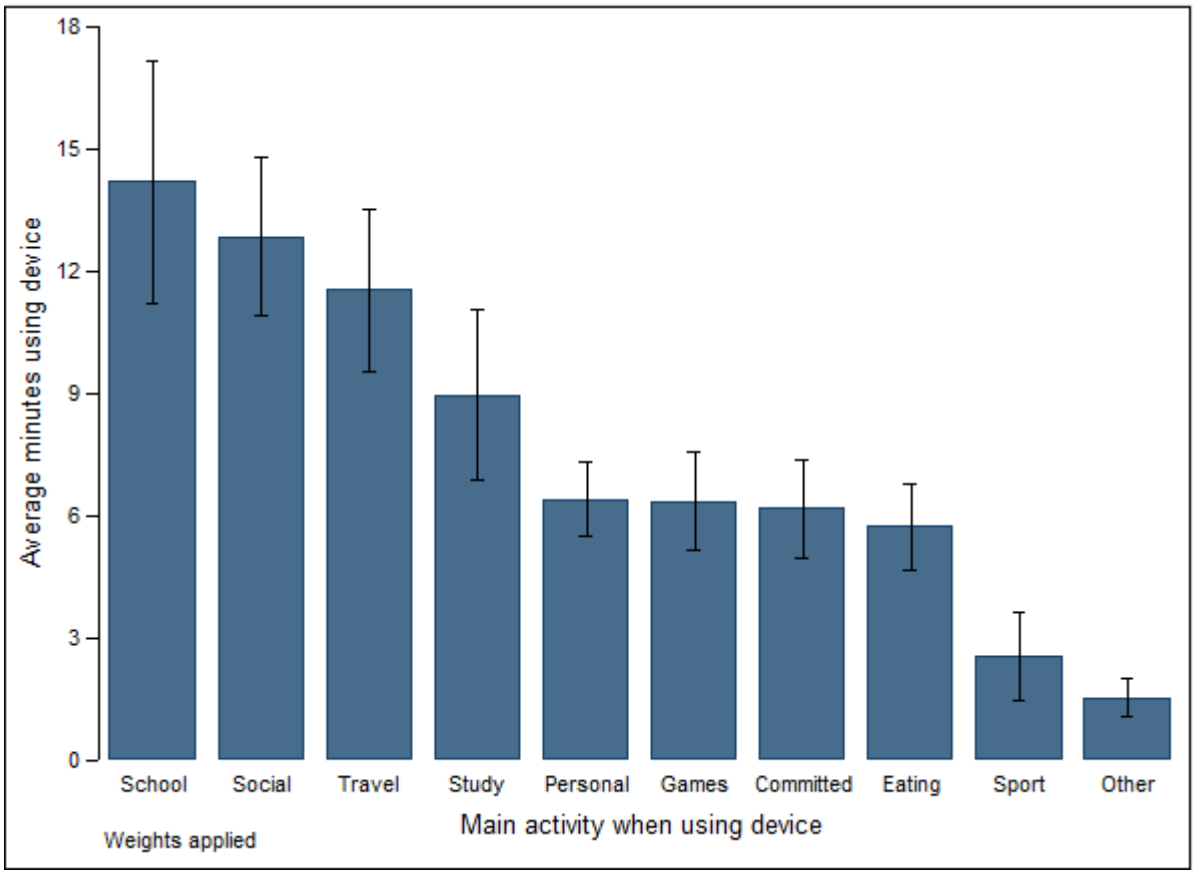


Table 4. OLS results from models of children's time (minutes per day) using digital devices when engaging in other activities

	School	Social	Travel	Study	Personal	Games	Committed	Eating	Total
Girl	1.7	3.8*	2.6	4.2**	4.3***	4.4***	4.3***	0.8	25.8***
12-15 years	8.6***	13.0***	12.0***	7.9***	6.5***	1.1	5.8***	4.2***	60.2***
16-18 years	19.1***	15.0***	15.4***	14.4***	8.0***	-3.6**	8.1***	5.6***	82.3***
Mother has a degree	-1.3	2.8	1.6	6.6***	0.5	1.2	0.9	0.5	12.9*
Mother works FT	3.6	-3.5	1.9	0.0	0.5	-0.4	0.9	0.0	1.7
Mother Works PT	0.1	-1.8	2.1	0.2	-0.4	3.6*	0.3	1.4	5.5
Lone mother household	-0.1	-0.4	2.3	-1.1	0.3	-1.6	1.8	-0.2	1.3
Household has no computer	1.7	-1.2	-4.4	-3.4	-0.7	-4.2	0.5	-1.6	-11.8
Household has no car	-4.6	3.5	2.2	3.8	-0.4	4.9	-1.4	4.1*	11.7
Number children 0-18 years	-1.7	-1.8*	-0.6	-0.5	-0.5	-1.1	-0.6	-0.6	-7.6***
Weekend	-15.2***	4.3*	-1.8	-1.3	0.1	2.3	0.9	0.6	-10.2*
Intercept	9.8***	2.3	0.4	-1.5	-0.3	2.6	-1.4	1.4	14.8**
Adjusted R-Square	0.05	0.03	0.05	0.04	0.06	0.01	0.03	0.02	0.13

Notes: N=2,179; Reference category: boy; 8-11 years; mother does not have a degree; mother not in paid work; two-parent household; household has a computer; household has at least one car; mean number of children 0-17 years; diary day is a weekday. *** p < .001; ** p < .01; * p < .05

Table 4 shows the results from a multivariate analysis of children's time using devices when engaging in a range of different activities throughout the day. Child gender and age were the strongest predictors of children's time using devices when engaging in a range of different activities. Girls spent significantly more time than boys using devices when doing social activities, studying, personal care, games, and during time doing housework and other committed activities. Turing to age, for every activity except games older children (12 years and over) were found to spend more time using devices than younger children (8-11 years). In addition to differences between children in the youngest age group and others, there were significant differences between children 12-15 years and older teenagers 16-18 years in device use when at school and study, and in total device use when engaging in other activities. In all cases, teenagers 16-18 years averaged significantly more time than children 8-11 years.

Strikingly, there were only a few significant effects for other covariates scattered across the models. Most notably, children with relatively highly-educated mothers spent more time using devices, which was concentrated in time when studying. However, considered overall, these results make clear that child gender and age are the dominant factors determining their use of devices when engaging in other activities. This exploratory analysis may be extended in future work by considering jointly the determinants of children time use both when using and not using technology.

Discussion

Over the past decade children and adolescents embraced new technology, incorporating it into many aspects of their daily lives. Against this backdrop, considerable debate around the benefits and risks of technology to children and young people is ongoing. One source of concern relates to the amount of time children spend in sedentary screen-based activities and the risk that this is displacing time in other activities, as well as leading to increased time in relatively solitary activities. These debates must be informed by good data on exactly how much time children are spending in these activities, and the extent to which this actually has changed. However, reliable data on children's time in screen-based activities are limited, with previous research primarily using recall-based measures known to be unreliable, and which cannot be combined to provide a complete picture of children's time in screen-based activities. Using two nationally-representative UK Time Use Surveys (2000-01 and 2014-15), this paper made three contributions to this important area of study: 1) it presented, for the first time in the UK (and elsewhere), an analysis of change between 2000 and 2015 in children's total time in screen-based activities as well as a decomposition of this time into different screen-based activities; 2) it studied key factors associated with children's time in screen-based activities, and whether the effects of these factors changed between 2000 and 2015; and 3) it analysed, again for the first time, the ways in which children today incorporate the use of digital devices into other, not directly screen-based, activities, and the determinants of this time.

Between 2000 and 2015, the total time children spent watching TV, playing videogames and using computers increased significantly. Although children's time watching TV decreased, by a relatively small amount, it was more than offset by increases in time playing videogames and using computers. These results suggest that we are some way off witnessing the demise of TV as the major focus of children's screen-based activity. Although these results imply a

limited amount of displacement between different screen-based activities, the net increase in screen-based activities found here must imply that children are spending less time in other activities on a given day. Some find that children's engagement in sedentary screen-based activities are poorly correlated with their engagement in physical activities (Marshall et al. 2006), suggesting that additional screen time detracts from time in other activities. Whether this is concentrated on a single activity (e.g. sleep, see Cain and Gradisar (2010)) or spread across a range of activities is an open question. Full consideration of this is beyond the scope of the present paper, and should be the subject of further research.

Change in screen-based activities is only part of the picture however. Dwarfing the increase in children's screen-based activities, reported as either their primary or secondary activity, is the increase in the time children report using devices such as smartphones and tablets, as well as computers, when engaging in other activities. This demonstrates the importance of including all devices when measuring children's time in screen-based activities, and appreciating that the use of devices now forms a part of the context of daily life. Some further implications flowing from this are discussed below.

Turning to factors associated with children's screen-based activities, we found that boys spent more time than girls playing videogames. There is nothing especially novel about this finding in itself, but we also found that the gender gap widened between 2000 and 2015. Added to this, we showed that gender differences in children's screen-based activities were concentrated in time playing videogames. In fact, there was no gender difference in total time watching TV or using computers in either 2000 or 2015. Consequently, the increase in screen-based activities (including videogames) between 2000 and 2015 was significantly greater for boys than for girls. This was, however, counteracted to an extent, though not fully, by the fact that girls spent more time using devices when engaging in other activities. These results align with previous research showing that boys tend to use technology to play games, whereas girls use it for school work, media, and to interact with others (Livingstone et al. 2014). It is important not to dismiss the widening gender gap in children's time playing videogames found here in essentialist terms. Although the perceived negative effects of videogames, especially violent games, dominate research, some positive effects of playing videogames for children's cognitive, social, and emotional outcomes are now receiving attention in the literature (see Granic et al. 2014). In addition, boys' early advantage in playing videogames introduces them to cultures and networks in the world of technology, and may help foster aspirations for valorised careers in technology. Set against continued male dominance in the technology industry (ONS 2017), future research could address the impact of gender differences in children's use of technology, wherever these arise, on pathways into careers in technology.

We found evidence of significant and persistent socioeconomic differences in children's screen-based activities. Children with highly-educated mothers spent less time watching TV and playing videogames, whereas children in families with no access to a car spent significantly more time in these activities than the majority who did have access to a car. That these effects were found at both time points is evidence of persistent (albeit not worsening) socioeconomic differences in children's screen-based activities. In addition, we found that children with a mother who has a degree spent more time using digital devices when engaging in other activities, especially when studying, highlighting socioeconomic differences in the way in which children are incorporating technology into their time in other

activities. This provides further support for the contention that the digital divide has less to do with access, and more to do with the way in which children are using technology and the internet (Holloway and Valentine 2003; Livingstone and Helsper 2007).

As already noted, children in 2015 are spending a substantial amount of time using digital devices when engaging in a range of other activities, indicating that children's use of devices such as smartphones and tablets are blurring distinctions between screen-based and other activities. The results do not suggest that much of this time using devices is time when they are engaging in traditional screen-based activities. Although we found that time watching TV and playing videogames as a secondary activity increased, for only a small amount of this time did children report using mobile devices. This suggests that these devices are being used mainly for other activities such as communication and interaction on social media, which accords with qualitative studies describing how children are using mobile devices to interact with family and friends throughout the day (Bond, 2014; Clark, 2014).

Characterising this as a 'screen-based' activity, akin to watching TV, is problematic. Some question the usefulness of the idea of 'screen time' in a world were screen-based devices increasingly are being used for a wide variety of purposes in a wide variety of different contexts (Blum-Ross and Livingstone 2016). It is suggested that we need to understand more about what children are using technology for and the social settings within which they are using it, rather than simply focusing on a total amount of screen time. While broadly in line with these arguments, the results of this study nonetheless underline the importance of efforts to measure and track children's time using technology (new and old) in order to fully understand how they are incorporating it into their daily lives. Though the focus here was on children's daily activities, research connected to this study is looking at the social contexts of children's use of technology.

Nowadays children also use digital devices when engaging in 'traditional' screen-based activities like watching TV or playing videogames. However, it is not clear from the current data when they are using these devices as the mode for the primary activity (e.g. watching TV on a tablet), or using them for another activity (e.g. using social media on a smartphone, while watching TV), that is, using of multiple devices for different purposes. Knowing more about what children are using devices for would shed further light on how children's screen-based activities are evolving with new technologies, but is beyond the capacities of the data used in this study. Future research drawing on both qualitative and quantitative data should develop work in this direction.

Information about what children are using devices for, along with information about other aspects of their time use throughout the day, would certainly add to our knowledge of children's screen-based activities. A further issue with the indicators used here is that they likely miss the use of devices whereby children are quickly checking updates and notifications, or reacting to social media posts, especially on smartphones. Arguably it is this way of using devices which looms large in our understandings and concerns about children's use of technology. However, the extent to which these instant (re)actions amount to a substantial amount of time over the course of a day is an open question. Nevertheless, there is no doubt that this comprises a key dimension of the way in which children (and others) use mobile devices, and we need to incorporate this in indicators of children's screen-based activities.

Conclusion

This study reveals much about children's engagement in screen-based activities, and how this has changed since the turn of the millennium. Increases in screen-based activities as a primary activity are concentrated in time playing videogames, and especially so for boys. Moreover, children today incorporate digital devices for a substantial amount of time into a wide range of different activities, with girls exceeding boys in this regard. We might speculate about whether developments in social media and the capacities of the internet would have progressed regardless of the invention of powerful mobile devices, arguably leading to a more substantial increase in screen-based activities tied to the use of immobile technology such as desktop computers rather than, as we have seen, an increase in time using technology while in engaging in a range of other activities. It might seem that technology has taken over children's lives, and we should be vigilant about this, but, and broadly echoing qualitative studies (Bond, 2014; Clark, 2014), the results here suggest that perhaps it is more accurate to view children as taking technology with them as they go about their daily lives. The implications of this for child well-being remain understudied, and future research should endeavour to bring together insights from both qualitative and quantitative data in an effort to better understand the influence of the technologies that are now clearly embedded in children's everyday lives.

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