

“I’m just on my phone and they’re watching TV”: Quantifying mobile device use while watching television

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ABSTRACT

In recent years, mobile devices have become a part of our daily lives—much like television sets had over the second half of the 20th century. Increasingly, people are using mobile devices while watching television. We set out to understand this behavior on a minute-by-minute quantified level as well as users’ motivations and purposes of device use while watching television. We conducted a novel mixed-methods study inside seven households with fourteen instrumented phone and tablet devices, capturing all app launches and app use durations, correlated with the moment in the television program when they occurred. Surprisingly, we found little difference between the volume of device use during programs and commercials. Our two main findings are that 1) participants often joined family members in the TV room to physically be *together*; when they lack interest in the program, they spend the majority of the show on a secondary device and watch TV only during key moments. 2) Virtually none of participants’ app and web use during TV consumption was directly related to the running show. With our study, we set the stage for larger-scale investigations into the details of mobile interactions while watching television. Our novel method will aid future work of the community as a means of fully understanding multi-device use alongside television consumption.

Author Keywords

Television; mobile devices; app usage; smartphone; tablet; indoor tracking; commercials.

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION

For many years, researchers (e.g., [1, 4]) and the press (e.g., [5, 12, 19, 20]) have been discussing “dual-screen” television viewers—people who watch television while simultaneously using another device, such as a smartphone or a

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tablet. While researchers have found that this is a common phenomenon via self-report surveys, to-date there has been no in-depth study on precisely how people are using their devices in conjunction with television viewing.

Many questions remain and no method that has been explored in the existing literature can fully answer them. For example, what percentage of mobile app use happens during commercials compared to during TV programs? And how does this compare to general app use throughout the day? Is application use different for different genres of shows? Does use increase or decrease during a program? Are the apps that people use while watching television different from those they use when they are not watching television? And which websites do they visit on their mobile devices while watching different types of television shows?

We designed a novel method to gather the data that is necessary to answer these types of questions, and ran a 14-day field study in 7 diverse homes to validate the capability of our method to capture complete data. To detect when a show is playing on participants’ TV sets and which show it is, we placed a logging device by their TVs that is capable of sound printing television audio. We also developed an app logger that records the time and duration of app use, and installed it on participants’ phones and tablets. Our app logger also records the web pages visited from the stock browser on the phone or tablet, including search queries.

Finally, we placed Bluetooth Low Energy (BLE) beacons throughout participants’ homes, such that our app logger could determine whether devices were in the same room as the television while the television was on. In addition, we complemented this quantitative data collection with in-depth qualitative interviews and voicemail diaries to capture an understanding of why devices were being used and what the social context of their use was.

With this deployment, we begin to answer the complex quantitative questions about app use during television viewing that to-date have not been fully explored. In this paper, we describe our method and discuss the findings that we derived from our field study. We believe that our method can be critical to actually understanding the nuances of device use during television viewing, which cannot be ascertained through interviews, surveys, or other self-reported means.

RELATED WORK

Despite the great amount of public press around the phenomena of second-device use during television viewing

[17], surprisingly little has been studied in-depth about its use. Research in this area tends to fall in one of several areas: self-report studies of use, studying online artifacts of second-screen use, or building new applications to engage users on second screens. In addition, unrelated to television viewing, other researchers have explored ways to log application use on mobile phones.

Several organizations have studied second-screen device use during television viewing. The PEW Research Center in the United States has conducted a large self-report study asking about people's everyday practices around phone and tablet use with television viewing [17]. They found that 38% of cell phone owners used their device during commercial breaks and that 22% used their mobile phones to check the validity of something presented in a television program. Of smartphone users, 20% looked online to see what others were saying about a program that they were watching (e.g., on Twitter or Facebook). Google also conducted a study and found that 22% of all simultaneous use of phones and tablets with television programming was complementary [8], meaning that the device use was in some way related to the content presented on the television screen. These studies show the prevalence of the phenomena, but they do not explore the details of these interactions beyond stating that they occur.

Cesar et al. explored early uses of second screens to interact with television content [4]. They found four main usage categories for these devices: Controlling, Enriching, Sharing, and Transferring content. However, this research was more exploratory and occurred before second screen devices were in regular use in the world. In 2011, Cesar and Geerts reviewed existing social television systems, many of which required the use of a second screen device [3]. However, again this was before these devices were in broad use, so little can be inferred about current everyday practices with a different variety of services.

Other researchers have studied the online traces of second-screen usage. Shamma et al. studied tweets that were posted during the 2008 American Presidential Debates [16]. They explored tweet volume over the course of the broadcast and found that the key moments of the debate could be identified from the online traces. PEW found that in the 2012 presidential debates, 11% of television viewers were also "dual screeners" and followed content related to the debates on their computer or mobile device [13].

Schirra et al. studied Twitter use during the British period drama "Downton Abbey" and explored the tension between paying attention to the show and viewing online content about the show [15]. They also found that social interactions on second screens provided an experience of being "together" with others while watching television, even if they were alone at home.

Through a diary study, Hess et al. explored second screen interactions while watching television [9]. Similar to the

PEW studies discussed above, they enumerated many of the activities that occur on mobile devices while watching television, many of which were completely unrelated to the content of the programming. However, they were not able to look in more detail at what participants did on a minute-by-minute level as TV shows progressed.

A final area of research has been in creating novel applications for second-screen interactions and studying their use. Nandakumar and Murray created an application for the TV series "Justified" that provided additional context about the characters and plot [11]. Basapur et al. created the Parallel Feeds system to provide related content to the currently playing TV program on a second-screen device [1]. The studies of these systems in everyday use showed the demand for systems that extend the content presented on the screen, an activity presumed to be one of the tasks that people frequently perform on their devices while watching TV.

While showing that dual screen usage is becoming a widespread phenomenon, none of these studies has tried to quantify exactly what people are doing on their secondary devices using today's applications. For example, which apps are participants using? How long are they interacting with their devices? How does interaction change during commercials compared to regular programs or vary for different genres? And how does interaction differ based on the type of second screen device, i.e. tablet or phone?

Finally, in studying application use, several researchers have created loggers that keep track of the apps that people use on their device. Böhmer studied app usage patterns in a large-scale field study, explicitly looking at apps that are used at certain times of day and at specific points in the day, such as before going to bed [2]. We see these technologies as an exciting opportunity to learn about fine-grained device use, but in the context of television viewing, a topic that previous app logging studies have not approached.

Overall, this literature shows that second-screen device use is prevalent, but not very well understood. With the exciting technologies of app loggers, there is a large potential to quantitatively study exactly what people are doing on their phones and tablets while watching television.

METHODS

We conducted a two-week mixed-method field study in the homes of seven diverse participants in order to understand mobile device use during and away from television viewing. The study contained both quantitative data collection procedures over the 14 days as well as several instances of deep qualitative data collection to help explain the quantitative data and the circumstances around mobile device use.

Participants

To collect representative data, we enlisted a recruiting agency to sign up seven diverse households in the greater San Francisco Bay Area. Six households were family homes with two or more persons and a couple lived in the seventh household. Our set of participants consisted of

three males and four females. Participants ranged in age between 22–57 (35.5 on average), and had a diverse set of occupations including nurse, analyst, office manager, and student. All participants owned Android smartphones as their main communication device and all also used an Android tablet. We captured data solely on each participant’s mobile device as well as on their main tablet using our app logger, but not on other devices in the household. All participants were compensated for their time.

App logger and indoor tracking on participants’ devices

We developed an app logger to inspect Android’s running applications, obtain their app and package name, and observe their launches and run times. Additionally, the logger recorded participants’ use of devices’ stock browsers to log time-stamped web histories as well as search queries. Any time the screen on the device was lit, our app logger captured this data. The app logger ran as a passive background process and became active only when the screen was lit. It thus did not impact app use or battery life of the device.

Each log entry was appended with the room in the house that the user was in (or nothing if outside the home). We implemented room-based tracking of devices using Bluetooth low energy (BLE), as is increasingly used for this application in commercial systems (e.g., Apple iBeacon). BLE beacons are short-range wireless devices that emit a unique address, which our app logger used as the signature to match a beacon from the known placement [18]. Our logger estimated locations using the known placement of BLE beacons around the participant’s house by interpolating between the signal strengths of all BLE beacons [6], which reveals the rough proximity to all beacon and enables the logger to estimate the location inside the home [14].

Our app logger triggered BLE scanning whenever the user accessed an app on the phone or tablet. The scanning continued for 30 seconds and the logger recorded the average value of the measured signal strength values for each of the beacons. The logger repeated the scanning every minute while a device was in use, but stopped scanning as soon as the phone screen was turned off.

Procedure

We conducted the study in December 2014 in three stages:

1) For the initial interview, we visited participants’ homes and conducted short, semi-structured interviews. The interviews covered their daily mobile device habits across both, smartphones and tablets, their general mobile search use and concrete examples of their most recent mobile search, details of their app usage habits across their smartphone and tablet, and finally their TV viewing habits.

At the end of the initial interview, we installed our app logger on participants’ phones and tablets and showed them samples of the app use data the logger would collect.

For the indoor tracking part of our study, we placed four BLE beacons around participants’ homes, primarily in the

living area, kitchen, and bedroom. We placed the final BLE beacon in a location to maximize our ability to discern the room with the main television from other rooms. While we could not verify absolute tracking accuracy, all participants’ homes were small and open-plan. All kitchens were connected to the living rooms, typically with a dining area or room as part of the living room. Hence, when our app logger detected the BLE beacon by the TV to be in medium range of the mobile device, the participant could hear and likely see the TV, which we considered TV consumption.

Finally, we placed a dedicated mobile phone that ran our sound-printing tool using IntoNow by participants’ main television sets. Our tool captured a 15 second audio clip every minute, generated a “sound print” on the recorded segment, and uploaded the features of this print to the IntoNow server for classification. No raw audio was ever stored or transmitted off of the device. The IntoNow server compared the uploaded features with its back catalog database of television programs that have aired in the United States since 2011 (including reruns) and returned a match upon successful detection. Matches identified the program with associated metadata (e.g., title, episode, genre) as well as the timecode in the show that corresponded to the audio clip. IntoNow also identified commercials.

Logging TV consumption with a dedicated mobile phone allowed us to know what participants played on the main TV in the home regardless of the source; our tool also identified content played through services, such as Netflix and Hulu, as long as the TV show or commercial had aired on US television in the past few years.

We only analyzed television sessions when the main participant’s device was in use and was close to the main television set. While the device we placed by participants’ TV sets continuously collected television logs, we discarded those that occurred when the participant was outside or used no apps on either mobile device at all.

2) For the 14 days of the study, we asked participants to leave a voicemail message once per day summarizing how they used their smartphone and tablet that day. During this same 14-day period our application logger ran in the background on their devices and pushed data about their daily app usage to our servers. Likewise, the television logger ran and pushed data about their TV consumption to our servers. All data was sent over a secure HTTPS connection and did not contain any personally identifying information.

We analyzed the quantitative data as follows. For each app event we logged in the app logger, we cross-referenced the TV logs to determine the running TV show or commercial and estimated the location of the participant’s devices using the BLE data. If no TV show was running or the BLE signals were out of range, representing the participant being outside their house, we discarded the respective app logs. Otherwise, we counted each app log either towards ‘TV program’ or ‘commercial’. When a commercial came on

and the participant decided to switch channels, for example, app use counted towards 'TV programs', since no commercial was actively watched. The app use we report for 'commercials' below thus exclusively represents times when a commercial was running.

3) At the end of the two-week logging period, we conducted a final in-home interview. Prior to the interview, we reviewed participants application use log data, their voicemail entries and their television viewing habits to list topics that we wanted to follow up on or get more details for. For example, we frequently asked about activity from their application logs that was not reported in their voice diary entries. Likewise, we probed about specific details of their app usage that occurred in parallel to watching specific programs and also asked if they had watched specific programs when they were logged as being in adjacent rooms to the television. This confirmed our assumption to count TV consumption during moments when participants were in the dining area of their house. Finally, at the end of the interview, we uninstalled the logging software from the participants' smartphone and tablet. All in-person interviews were audio recorded and transcribed and all voicemail dairy logs were transcribed to prepare for data analysis.

We analyzed the qualitative data using grounded theory and thematic analysis. We looked for repeating themes in participants' responses during our semi-structured interviews at the beginning and end of the study as well as in the voicemail data that participants provided throughout the study. The items of analysis were quotes from participants, which we combined to form the themes.

Results

Overall, the seven households in the study watched 415 hours of TV during the two-week study period. In total, they launched 1,447 apps on their phones and 485 apps on tablets, using their phones for a total of 867 hours and their tablets for a total of 497 hours. Half of all device usage occurred when participants were at home. On average, 2.8% of all app use occurred simultaneously on both devices. In their mobile browsers, participants visited a total of 1,343 web pages, 770 web pages from their phones and 573 web pages from their tablets. They performed 153 search queries through web search engines, such as Yahoo and Google, with 129 searches submitted from their mobile phone and the remaining 24 from their tablets.

During the time participants watched TV, they interacted with their phones for a total of 77.8 hours (17.9% of all phone use while at home) and tablets for 37.2 hours total (7.5% of all tablet use while at home). Participants accessed 136 web pages while watching TV (133 unique web pages, 43 unique domains) and conducted 28 web searches (15 unique queries) across both tablets and mobile phones. Most of these web pages were accessed via tablets (120 of the 136 webpages, 88.2%).

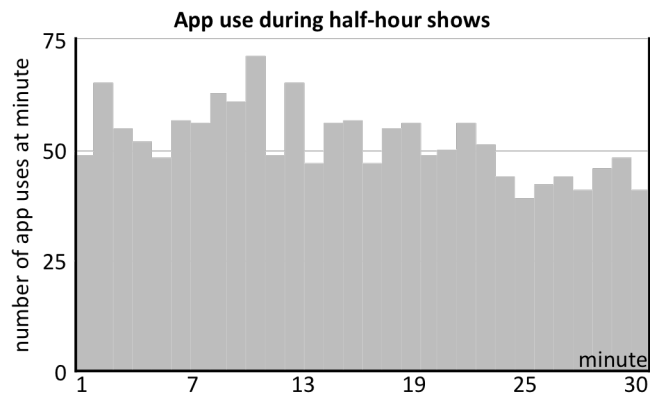


Figure 1: The number of times any app was used at each minute of all 30-minute shows. Note the fairly consistent use over the course of the program.

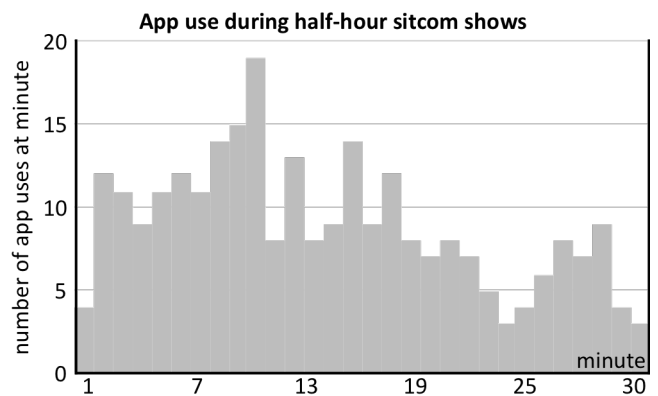


Figure 2: Histogram of app use during half-hour sitcoms. Note the sharp decline towards the end of the program.

App use during TV programs for different program genres
 During the study, 21.2% of all of the shows that participants watched were a half-hour in length and 34.5% were one-hour shows. These were the two most-frequently watched show durations during the study and there were smaller numbers of 1.5, two, and three-hour programs. We present our analysis of app use separately for the most frequent show durations below.

Figures 1–3 illustrate the times during a TV show when participants interacted with apps on their devices. Figure 1 shows a histogram over all half-hour shows. Figure 2 shows this distribution for half-hour sitcom shows. App use generally declined after the typical point of the first commercial and waned even more towards the end of the program.

Figure 3 illustrates the histogram of app use for one-hour shows. We see an increase in app use during the middle part of the show, which tapers off again towards the end of the show. The large drop in app use around the 54-minute mark is likely attributed to the final twist of a show just before the last commercial upon which app use shows a final peak.

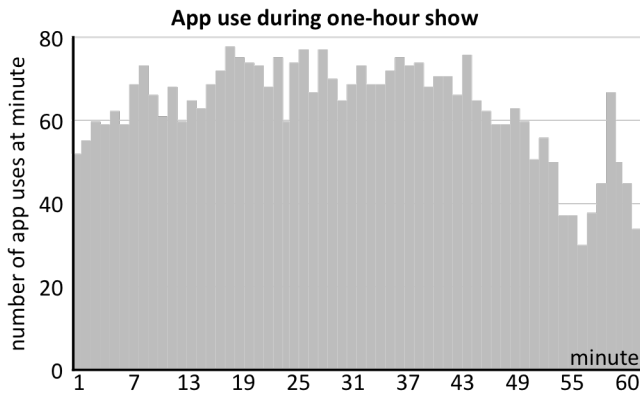


Figure 3: Here we show the number of times an app was used at each minute of a 60-minute show. Note the higher use throughout the show compared to 30-minute shows in the previous figure, and a spike at the end of the program.

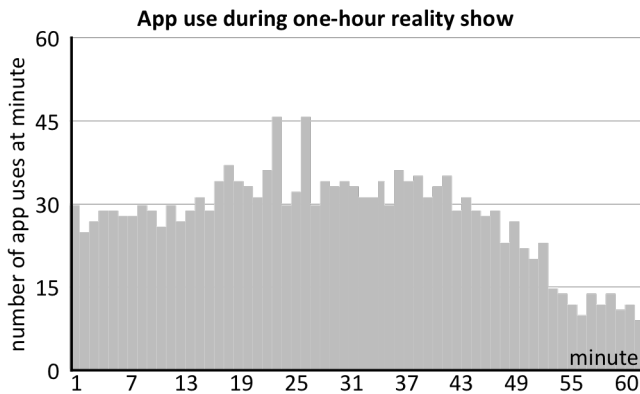


Figure 4: App use is fairly steady throughout one-hour reality shows, except for a large drop towards the end, typically when a candidate is selected to leave the show.

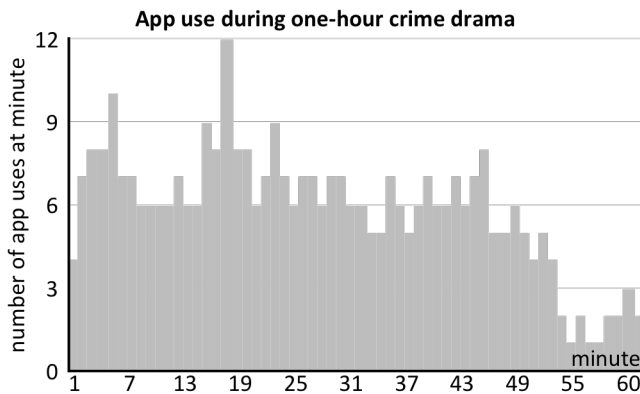


Figure 5: The app use pattern for one-hour crime dramas shows many fluctuations, which correspond to the times of commercials. Participants' lowest app use throughout crime dramas was at the end when the show's mystery is resolved.

Turning to exploring a particular genre for one-hour shows, Figure 4 displays the subset of app use for reality shows. During such shows, participants' use of apps was mostly steady (and higher than during other genres) with a peak in

app use around the 25-minute mark, a point that typically begins the longer mid-show commercial break. Otherwise, app use was fairly steady throughout the show, which is likely due to the rather steady level of suspense in such shows. The end of the episode marks a clear exception, where we can see a substantial drop in app use. This is often the moment when a particular candidate is selected to leave the show that week in a typical reality show, such as *Survivor* or *The Bachelor*.

Figure 5 shows the app use for one-hour crime dramas. The histogram shows a spike at the typical point of the first commercial break around the 15th minute. Similar to the histogram for reality shows, the final drop in app use is likely due to the resolution of the show's arc of suspense.

Times of watching shows

Figure 6 shows the times during a half-hour or one-hour show when participants were actively watching a show in a particular genre. Especially apparent in the 60-minute programs, there was a dip in program viewing in locations typically associated with commercial breaks, around the 25th minute and the 45th minute. In the data, we also saw channel surfing at these times in many viewing logs.

We explored the average time a user continuously watched a program. For example, if a participant watched a show for seven minutes, then tuned away for three minutes, and finally tuned back to the first show for the remaining 20 minutes, this would consist of three sessions (3 minutes, 7 minutes, and 20 minutes). Durations had local maxima around five and ten minutes, as well as just before the half hour mark. This, along with the previous figure, indicates that during the majority of time participants switched to different television channels once commercials came on.

Commercials compared to programs

Of the 415 total hours of TV watched, participants watched 14.9 hours of commercials (3.6%). While participants used a device 35.2% of the time during programs, they used it 30.2% of the time during commercials. Interestingly, while the overall smartphone usage went down during commercials, tablet usage went up: We found that on average participants used their mobile phones during 25.3% of the time of programs and 19.9% of commercials, while they used their tablets during 12.8% of programs and 12.4% of commercials. Simultaneous use of participants' smartphone and tablet devices dropped from 2.9% during TV programs to 2.2% during commercials.

During programs, participants on average launched 0.06 apps per minute on their phones and 0.02 apps per minute on tablets. During commercials, they launched only 0.04 apps per minute on their phones and maintained an average rate of 0.015 apps per minute on tablets. We saw a decrease of app launches for phones during commercials as well as an overall decrease in commercial viewing as shown in Figure 6, which indicates that participants either quickly

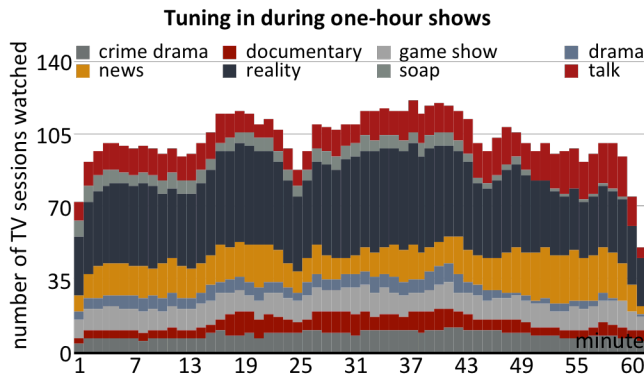
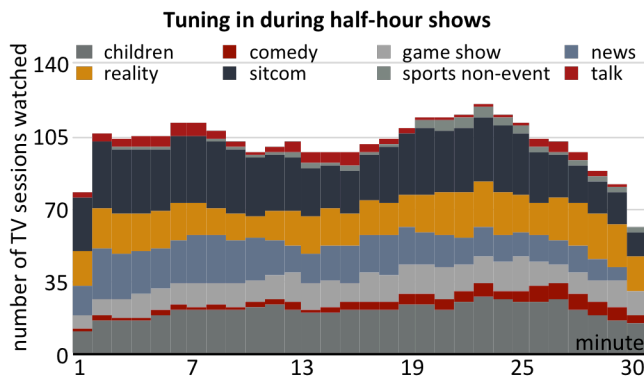


Figure 6: Times in program when participants were watching regardless of app use. Drops occurred at typical commercial breaks, such as at 25 and 45 minutes during one-hour shows.

flipped channels or used commercials for other activities, such as going to the bathroom or a different room.

The median duration of app usage on phones was 22 seconds on average for apps launched during programs and 19 seconds during commercials. Tablets showed the same trend with an average duration of 17 seconds during programs and 89.5 seconds during commercials. To obtain these numbers, we counted an app launch once for the type of TV show that was running (e.g., program or commercial), but split app runtimes when TV shows changed, such that the respective part of app runtime is always allocated to the running TV show or commercial.

Duration of app use

Comparing phone with tablet use, participants used their smartphones for shorter interactions while they interacted continuously with tablet applications. Interestingly, participants used apps on tablets longest during sports talk shows (3.1 minutes on average), sports non-events (3 minutes), sports events (2.7 minutes) and news (2.2 minutes). On phones, participants used apps longest during children shows (1.6 minutes on average), action and adventure shows (1.5 minutes), and talk shows (1.4 minutes).

Three large spikes appear when looking at app durations. The first peak during five-second interactions indicates a quick interaction with an application (e.g., viewing a text message) after which participants exited the app. This is

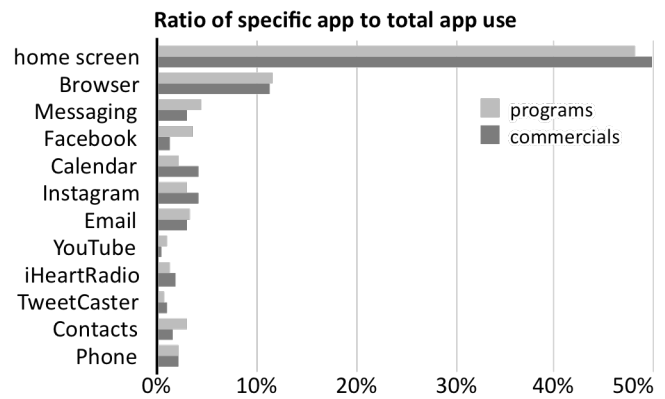


Figure 7: Percentage of use for an app during television viewing compared to all apps used. While Facebook and YouTube were popular apps during TV shows, both saw substantially less engagement during commercial breaks.

quite different from app use outside the home, where after a typically short session the screen will be immediately turned off as the phone is put away. For example, Ferreira et al found that 40% of all app usage throughout the day is 15 seconds or less [7]. The wide spread of the last peak in the diagram between seconds 70 and 130 shows longer durations of interacting with an application such as browsing a Facebook feed or writing a reply to a message.

Types of applications used

We will now investigate the specific applications that were used while watching television. The browser, messaging and social network applications were most popular during TV consumption as shown in Figure 7. Most applications experienced a decrease in use during commercials. For example, Facebook dropped from 3.7% to 1.4% of its usage during programs, a difference of 38% (Figure 8). Equally interesting is that participants spent more time in the Calendar during commercials (rising from 2.2% to 4.2%).

Differences in app use by TV genre

Splitting app use by TV genres, we can see that certain TV genres provoke substantially more app use than others as shown in Figure 9. While TV genres such as comedy, sports, and romance prompted participants to use apps on their devices in more than two thirds of the time of a program, documentary-style genre such as nature, animals, history or science saw very little app use. These types of shows are providing more information per minute of program and often build on the data presented earlier in the show as the program continues which might be causes of the decreased application use.

Web and search use

Moving from app use to the specific URLs visited in the browser, we examined the websites participant surfed while watching TV along with the web searches they conducted during that time. Figure 10 lists the top 10 most accessed domains from the mobile browser while watching TV. Our goal was to get a sense of the type of websites participants visited and to determine if the topics or scope of the sites

program			commercial		
1	home screen	48.1%	1	home screen	54.1%
2	Browser	11.6%	2	Browser	11.4%
3	Messaging	4.4%	3	Instagram	4.2%
4	Facebook	3.7%	4	Calendar	4.2%
5	Email	3.4%	5	Email	3.1%
6	Instagram	3.1%	6	Messaging	3.0%
7	Contacts	2.9%	7	Phone	2.1%
8	Phone	2.3%	8	VpnDialogs	2.0%
9	Calendar	2.2%	9	iHeartRadio	1.8%
10	iHeartRadio	1.3%	10	Contacts	1.7%
11	YouTube	1.2%	11	Facebook	1.4%
12	TweetCaster	0.8%	12	Xfinity TV Go	1.1%

Figure 8: Ranking of apps by proportional use during TV programs and commercials. During commercials, apps with quick interactions (e.g., Facebook, Messaging, Instagram) saw less engagement than those apps that require longer interaction, such as Email and Phone.

Top apps			Bottom apps		
genre	usage	#	genre	usage	#
comedy-drama	68.5%	13	action	16.2%	20
sports non-event	68.5%	41	horror	14.2%	18
sports event	61.5%	296	documentary	11.8%	53
romance-comedy	53.2%	14	soap	7.6%	6
music	47.8%	29	science	6.7%	6
sports talk	42.2%	17	entertainment	6.6%	10
crime drama	41.9%	96	newsmagazine	5.0%	24
bus./financial	40.0%	11	history	3.8%	17
reality	39.7%	272	animals	< .1%	5
news	37.1%	79	nature	< .1%	4

Figure 9: Top 10 and Bottom 10 TV genres during which participants interacted with apps for a fraction of the time.

was related to the genre of the TV show in question, as suggested by previous work (e.g., [8]). In participants’ logs, five of the top domains relate to top-trafficked websites, including Google and Facebook. We also found some sites that are knowledge bases, such as eHow, and sports-related sites like ESPN. The remaining URLs relate to shopping websites, such as Amazon and Urban Outfitters.

Surprisingly, on closer inspection, we found that none of the web pages or domains participants visited while watching TV related to the content of the programs being watched. This insight stands in sharp contrast to previous findings that show higher levels of complementary use (e.g., Google’s report [8] and Pew’s study [17]).

Next, we analyzed web searches that participants made from their phone or tablet during television viewing. Of the seven participants, we found that only three executed a search query while a television program was on. Of the 15 unique mobile search queries entered while watching TV, none of the queries appeared to be related to the topic or genre of the currently playing television program and none of the queries were issued during a commercial. Some of the example queries issued during TV use include “*spurs*

Domain	Percentage of all domains
www.google.com	20.6%
www.amazon.com	9.6%
www.facebook.com	7.4%
m.yelp.com	5.9%
m.facebook.com	4.4%
truseelforganics.com	4.4%
m.espn.go.com	2.9%
www.ehow.com	2.9%
www.surveymonkey.com	2.9%
smcl.bibliocommons.com	2.2%
www.urbanoutfitters.com	2.2%

Figure 10: Top 10 domains accessed during TV watching.

female coach”, “*urban outfitters*”, “*hair salon in san mateo*”, “*yahoo mail*” and “*kim kardashian*”.

Finally, we analyzed whether any of the search queries across all participants over the two-week period were entertainment or TV related. We examined all queries submitted through Google, Yahoo and Bing and verified whether or not the participant was watching TV at the time the query was issued. We found a total of 153 mobile search queries submitted over the study period, 80 of which were unique. The following queries were TV related: “*money in the bank wwe*” (“Money in the Bank” is a professional wrestling pay-per-view event), “*tablet tv*” (while not related to any TV show per se, it is related to watching TV on tablets), “*bridesmaids*” (P2, who later watched the reality show “*NeNe’s bridesmaids*”) and “*victoria’s secret show 2014*”, which is a fashion show that can be watched online. Three other queries pertained to personalities in television shows: “*kim kardashian*” “*spurs female coach,*” and “*kylie jenner plastic surgery tumblr.*” Compared to self-reported findings in the literature (e.g., [8, 17]), we again saw only little activity related to the current TV show or commercial.

What people were doing

Turning from the quantitative logs, we now explore some of the motivations for participants to use a second screen device during television programs. As mentioned in our methodology section, the themes we list below result from participants’ quotes during our interviews at the beginning and end of our study as well as participants’ voicemails. Each theme was supported by multiple users and will be discussed in the subsections below.

I want to be with my family

Participants frequently discussed times when their partners or children wanted to watch programs that they themselves were not very interested in watching. In many of these instances, our participants still wanted to be physically with their family members, but reported spending large chunks of the show using a device instead of paying attention to the show. This still allowed the family to be together, even if everyone wasn’t focused on the television.

We asked P2 about app use while watching TV and she told us that “*It’s usually because I just want to be in the same*

room as them and I'm doing my own thing." P3 also talked about the desire to be with her family while watching television: "The kids always take over the TV and I can never watch what I want to watch unless I go upstairs, but then I'm not going to be with everybody, so I just stay on my phone down here." During these times, she often does not pay attention to the television: "I think I was doing my own thing, but I was relaxing at the same time, and I was playing with the baby, so I guess [looking] half and half."

P7 discussed several instances of device use while his wife was watching television. He went on Twitter "probably just more out of boredom. I don't think that it's necessarily related to the television show or whatever I was watching. It was just, it may have been something my wife wanted to watch and I just couldn't get into it."

This can be confirmed as a more general pattern with the quantitative log data. For example, device use stayed high during most shows as shown in Figures 1 and 3. The qualitative data was able to add the interpretation to this data indicating that the participant often was not interested in the programming at all, and just wanted to be with their family.

In these cases, device use is almost always unrelated to the program being watched. It is the desire to be with family that drew participants to the same room as the television, and since they were not interested in the show, they did their own thing on their devices. We discuss some of these activities in the subsections below.

I get things (household chores) done

Often, participants discussed using time in front of the television to catch up on household chores using their mobile phones and tablets. P5 was using an app for her bank to review her recent spending: "I was just adding all my transactions. ... I was always on my Citibank app. I don't manage my account like, I don't know, other people do, one by one. I just pay attention to how much I have and I was like, 'Okay.'" P2 used television time while watching the news to catch up with friends and household tasks: "I will send texts when, so when they're watching something I will be sending texts to get some things done and out of the way."

These participants were not always paying attention to the television, and the activities that they performed while watching television were related to household tasks and non-show related communications. As much existing literature has shown [9], in these cases the television was more background noise rather than the focus of attention.

The quantitative data also helps to support this use case, with 415 total hours of television watched across households (an average of 5 hours a day). It is unlikely that all of this time was spent actively watching TV programs.

TV in the background while consuming unrelated content

Beyond the functional tasks of household chores or communication mentioned above, app use was frequently unrelated to the television show. In some cases, it even involved

seeking another entertainment purpose. Returning to the log data, Figure 8 highlights the wide variety of apps used during programs, including other sources, such as YouTube. For example, P5 searched for YouTube videos and watched them with her kids while watching a pseudo-science show: "We watched a lot of YouTube videos like old songs while watching TV ... We were all here watching TV. I think I was watching my reruns and my Ancient Aliens while I was on the tablet looking for ... I like to go to YouTube to look at ... I'm into 80s music, so I search a lot 80s music, and then I was searching a lot of just R&B, old songs from when I was young. ... I like to share with my kids." In this case, a repeat episode was on television, so instead of paying much attention to it, the family browsed videos on a tablet.

P2 discussed web browsing during sports event: "I know that I will browse a lot when I am watching basketball. I can hear and I don't necessarily have to watch, so I can be doing something else with my phone and hearing the score." For him, it was not necessary to watch every basket. Instead he kept the game on to hear the ambient noise of the game and would glance up to see the score or major plays.

P7 discussed not being engaged in the TV show and checking email and browsing Twitter. "It's probably why I was checking emails. It's maybe one of those evenings where I wasn't particularly engaged in whatever we're watching." P6 discussed using commercial breaks to catch up on other activities on his phone: "I think I totally just disconnect with commercials. I pay attention and I don't. I could be doing multiple things, but yeah, I guess maybe that is a time that I use a break to do other stuff. Especially if it's a program I really like and I don't want to be disturbed."

For many participants, device use became an everyday part of watching television. P6 spoke about how there are no tensions when family members use devices while together watching television: "No, we're all on devices. We don't get offended about it, and my daughter has her own little device that she plays stuff on. We actually like technology." P3 talked about how natural it has become to use a device while watching a program: "I probably do it all the time ... I don't keep track of it, because I guess it's a natural thing. When everyone is here I'm just on my phone and they're watching TV, or Sunday, the games, that's a good example ... My mom's family comes here every Sunday, and that day is meant for football, all day watching football."

However, P5 spoke about how sometimes there is a tension around watching TV together as a family: "It's very hard to watch a movie with all of us here ... my husband always says that, 'Gosh, we can't even watch the movie because you're always on the phone,' ... I think it's just a habit of ours to put something on TV, I guess to see it for a little bit, but not really pay attention." However, she said that this did not stop her, or her children from continuing to use devices while the television was on.

Overall, participants used devices for many activities that were unrelated to the TV show they watched. In many cases, the show itself was just background noise or visual distraction while participants watched online videos, communicated with friends or family, or browsed social networks.

I look for things related to the current show or commercial

Device use often went hand in hand with watching sports. For example, looking up scores, information about related teams or details about fantasy football teams. P7 uses the CBS sports app to look up player stats while watching a basketball game *“I use this one app because I was watching a basketball game ... I’m watching the Razorbacks and they’re telling stats but they don’t have the stat that I want to see, so I can look on the CBS sports app and I can see all the players and what their stats are, in the middle of the game, regardless of what they’re telling me.”*

P4 discussed checking scores for his fantasy team while the Sunday game is on in his household with friends, which at times cause some tensions, *“I like to check scores a lot cause I have a fantasy team so I’ll have my phone out just checking scores. More often than not, others in the room might also be on a fantasy team. It kind of alienates a few other people when they’ll bring out their phone and check out the real time stats ... You get looks from others who don’t play and they’re like, ‘Hey, you’re in a social situation, put that thing away.’”*

P3 talked about using her phone to look for things related to sports only if she misses something, e.g., *“Unless I miss something and I come later in the day, or I’m out all day and I come back and I want to know the score, then I would do that, but when I’m watching the game I don’t search about the game on my phone, it’s about other stuff.”*

Aside from sports there were other examples of searching for things related to what was being watched on TV. As shown from the log data in Figure 8, browsers (and search in browsers) were often used during commercials. P6 talked about a commercial leading to her purchasing a toy car for her daughter, *“If we’re watching a show and I see something I like, and to figure out the brand, we may go on and try to find it. ... we watch the show, and the commercials showed that car, and we bought that for my daughter.”*

Television content, especially sports and commercials, led to a small amount of related application use. Here, the app use complemented the programs, in line with previous “complementary use” reports, yet at a much reduced level compared to previous findings (e.g., [8]).

Limitations

While the TV and app use dataset we collected during the study is very comprehensive, it is not perfect. The device that kept track of television viewing ran sound printing only over a period of 15 seconds each minute, which may have caused misclassifications or alignment issues with the beginning of commercial breaks, even when we broke down analysis by minute. Mislabelings in the soundprint data may

have also occurred also because some shows feature flashbacks of previous episodes, previews of future episodes, or because of commercials that advertise other shows. To help combat this, we leveraged the longest duration matches (15 seconds) that IntoNow supports to limit misclassifications. Finally, the IntoNow catalog does not comprise TV shows that have not aired on US satellite television, such as Netflix-only shows (e.g., *House of Cards*) or an Argentinean news program that one participant watched and would thus not be included in our numbers.

Another limitation is BLE-based tracking of *accurate* indoor locations. Older hardware in commodity devices and low battery levels may have impacted measurement accuracies. Such misclassifications could include participants that were located in a different story of their building but directly above the TV. However, tests of our setup in each of the authors’ homes showed a tracking accuracy of 87%.

Finally, a sample of seven households, while still collecting hundreds of hours of television viewing and many thousands of application launches is not representative of the American population as a whole. We conducted this study in part to test our novel method of exploring device use, and to uncover initial trends that can be validated by larger-scale studies in the future, which is the natural next step.

Discussion and Implications

While previous work in the area of multi-device use in the home has sourced data primarily from surveys, in this work we provide a quantitative investigation of simultaneous TV consumption and app use on phone and tablet devices in addition to a qualitative analysis. Logging app use on such devices on a minute-by-minute basis during the study allowed us to precisely analyze device interactions and correlate them with events in each show, such as commercial breaks or identify trends over the course of a TV show. This analysis allowed us to produce a number of key findings, which we will now discuss in more detail.

During a large amount of TV consumption, the focus of the participant was frequently on their mobile devices. While this often occurred when participants desired to be in the same room as their other family members, but were not interested in the particular show that they were watching, we also observed a large amount of television watching in the background. This is particularly true of shows that require only little attention during the longest part of a show, such as sport events, comedy, reality, or romance shows. Here, TV served the function of background entertainment, sometimes used only for background sound exposure, while participants spent a large amount of time in apps on their mobile devices. But in the case of reality shows and crime dramas, the reduction in app use at the “reveal” moment at the end of the show illustrates viewers often re-engaged in the program at the key moment.

In contrast, TV programs that inform and educate their audience received much larger amounts of focus from partici-

pants, who engaged with applications only in a very small fraction of the time during shows in genres such as news, science, and history documentaries. Our data shows that during these shows, the program often serves a larger role of an active focus. Another potential explanation is that social conventions may prevent people from chatting with others during active shows that may be interesting to other members of the family, whereas it is generally okay to talk during sports or reality programming.

Our minute-by-minute analysis also uncovered interesting insights into participants' behavior during commercials, during which the average percent of time that participants interacted with devices changed only by a very small amount. Interestingly, during commercials participants spent more time in applications that seemingly take longer to interact with, but certainly require more focus, such as phone and email, compared to messaging and social networking during shows. The numbers, however, indicate that participants spent an even shorter average amount of time per app interacting during commercials.

Our study also opens up further questions for follow-up studies. In particular, we believe that our method can be used to answer a wide variety of other research questions. By analyzing a larger number of households across different regions and countries, statistically meaningful results can be found comparing cultures and genres of television programs. This information can be used by broadcasters, advertisers, and app creators in order to develop more engaging experiences for viewers.

CONCLUSIONS

We have described a study that investigates television consumption and simultaneous app and web use on phone and tablet devices. In this study, we collected data from the televisions of seven households and 14 phone and tablet devices with over 415 hours of consumed TV shows, 1,364 hours of phone and tablet use, 1,447 launched apps with room-level location, in addition to detailed qualitative interviews and voicemail diaries. We have shown how mobile devices are used at a minute-by-minute level during TV programming, the role of televisions (and importantly the act of being in the television room) in the context of the broader family at home, and how participants divide their attention in different television genres.

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