Design Guidelines for Notifications on Smart TVs

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ABSTRACT
Notifications are among the core mechanisms of most smart devices. Smartphones, smartwatches, tablets and smart glasses all provide similar means to notify the user. For smart TVs, however, no standard notification mechanism has been established. Smart TVs are unlike other smart devices because they are used by multiple people - often at the same time. It is unclear how notifications on smart TVs should be designed and which information users need. From a set of focus groups, we derive a design space for notifications on smart TVs. By further studying selected design alternatives in an online survey and lab study we show, for example, that users demand different information when they are watching TV with others and that privacy is a major concern. We derive according design guidelines for notifications on smart TVs that developers can use to gain the user's attention in a meaningful way.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous

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Notifications; Smart TV; TV; Attention; Guidelines

INTRODUCTION
Today's mobile devices and traditional desktop computers inform about new messages, upcoming appointments, events, and general hints using notifications. Notifications are a well-established mechanism to inform a user about a diverse range of information. One of the main use cases is enabling asynchronous communication. A typical notification related to personal communication on all major platforms informs about the sender and shows a text excerpt. In recent years, notifications became one of the core mechanisms on a number of smart devices.

Notifications can provide time sensitive information. They, however, do not always reach the user in time, because the device is not in the user's range. Dey et al. [6], for example, showed that users' smartphones are only within arm's reach 53% of the time. Already in 2002, Want et al. [23] proposed to distribute notifications across different smart devices. Sahami et al. [21, 24] developed a system that forwards smartphone notifications to desktop computers. Recently, major smartphone platforms started to provide centralized notification mechanisms. Notifications are not only managed on a single device itself but collected and shared across smartphones, tablets, desktop computers and laptops. Furthermore, a number of new types of smart devices recently became available. The core feature of smartwatches and smart glasses is displaying notifications. Studying smartwatch users, Lyons [16], however, found that 24% of the 50 participants did not wear their watches at home.

Another highly successful type of smart devices are smart TVs. The main characteristic of smart TVs in comparison to regular TVs is the capability to process data and to connect with online services. Thus it is possible to stream videos and other content from the Internet. Unlike mobile operating systems, there is currently no dominant operating systems for TVs. There is, however, a clear trend towards platforms similar to mobile operating systems, including the possibility to extend the systems by installing apps from app stores. In contrast to other smart devices, current smart TVs have no established notification mechanisms. Displaying notifications on smart TVs poses a number of challenges. TVs are primarily used for watching content, including TV series, news and movies. Displaying notifications on top of the main content can result in distractions and therefore affect the TV experience. Furthermore, unlike smartphones or smartwatches, TVs are shared devices that are used by multiple people, often at the same time. Therefore, the notification mechanisms designed for other smart devices cannot directly be adopted for smart TVs. Instead, it has to be investigated how a pleasant notification experience on all devices can be achieved while respecting the users' attention and privacy.

In this paper, we develop design guidelines for notifications on smart TVs. The paper is structured as follows: Through a series of focus groups we first explore design alternatives that potential users envision. Informed by this design space we further study five different design alternatives in an online survey. Based on the results we develop a customizable smart TV application that is able to display notification whilst watching TV, which we use to conduct a lab study. Combining the findings of the focus groups, online survey and lab study, we derive design guidelines for notifications on smart TVs. These design guidelines can be used by developers of future TV systems to gain the user's attention in a meaningful way.

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RELATED WORK

The main characteristic of smart devices is the ability to connect to other smart devices and the Internet. In the past years existing devices and everyday things got smarter. With mobile data networks it is possible to access the Internet on the go and with smartphones it can be carried in the pocket. Smartwatches and smart glasses extend smartphones and are always with the user. Smart TVs are able to stream content from the network, thus transforming the TV from a device that was used mainly for watching television to a large screen that is able to receive content from various sources. The connectivity of smart devices allows pushing messages to the devices which lays the foundation for notifications. When receiving a push message, smart devices can alert the user through multiple modalities, namely visual cues, auditory signals and tactile output.

On smartphones notifications are a central interaction mechanism. Most current mobile operating systems allow the list of pending notifications to be accessed from any screen with a simple gesture. Previous work studied the effect of notifications on desktop PCs, smartphones and smartwatches. In an in-situ study with 15 participants, Pielot et al. investigated how users interact with notifications. Over the course of one week participants received an average of 63.5 notifications per day, mostly from instant messaging and email applications [19]. Furthermore, the study showed that notifications are viewed within minutes, even when the smartphone was put in the silent mode. Sahami et al. conducted a large-scale analysis of smartphone notifications by collecting 200 million mobile notifications from 40,000 users [21]. They found that notifications are viewed in a timely manner, with 50% being viewed within 30 seconds. The results of the analysis show that notifications related to messaging, communication and calendar events are the ones that are most valued by users. Furthermore, the authors conclude that important notifications are about people and events.

Research on interruptions caused by notifications predates the current set of smart devices. Czerwinski et al. investigated the effects of interruptions on task switching on traditional desktop PCs [5]. According to studies conducted by Iqbal et al., notifications cause interruptions but are still valued by users because they provide awareness [12]. Research has shown that the disruptive effects of notifications can be reduced by timing notifications. By issuing notifications at the end of tasks it is possible to maintain high awareness and reduce the disruptive effects of notifications [1]. Fallman and Yttergren proposed a system for mobile phones that detects nearby users and chooses an appropriate notification modality accordingly [7].

Today, multiple devices are often used at the same time. Smartphones are, for example, becoming a second screen for the TV, offering interactivity through social networks [15]. Nathan et al. implemented CollaboraTV, a system for asynchronous interaction with the goal to bring people together even if they do not watch at the same time or place [17]. The results of a field study over the course of one month showed participants valued the system. Alaoui and Lewkowicz proposed a similar system for elderly to cope with loneliness [2].

Holz et al. found in a study that family members joined each other in the living room to be physically together [11]. Courtois found there are three types of TV watching behavior [4]. One type only focuses on the TV, the second type watches TV with second screens, for example tablets or laptops, and the third type uses seconds screens and even printed media.

Further work has been done in the field of program recommendation systems for TVs. Chang et al. give a literature overview and, based on the gained insights, propose a recommendation framework [3]. As recommendations are based on the user's interests this creates challenges for multiple users. One possible solution for these challenges is merging interest profiles from the people in front of the TV, as proposed by Shin and Woo [22]. Lee et al. proposed a system for smart TVs that can authenticate the user using face recognition [14]. This can be used to automatically change the program recommendations depending on the user in front of the TV. Furthermore, the researchers propose using hand detection to control the smart TV with natural hand gestures.

Regan and Todd explored a system that allows multiple users to access their instant messages while watching TV simultaneously [20]. They state that people often use their PC to communicate in addition to watching TV. They looked at the aspects of privacy and distraction caused by such a system when watching TV with multiple people in the same room. To make users aware of incoming messages they used pop-up alerts in the corner of the screen, similar to ones found on the PC. In a study they found that for some people access to instant messaging is important even when watching TV. In the study incoming messages were considered interrupting if they were not meant for the participant.

Hess et al. conducted empirical work on concepts for social TV experiences [10]. They state that through current technology the Web and TV is combined which enables users to share content and communicate with others over distance. They identified a trend that watching TV is supplemented by other media. Multiple devices are used simultaneously, e.g. for communicating with friends. In a workshop a group discussed notifications. Messages should be received on the smartphone but users should be able to decide whether a notification should be displayed on the smartphone, the TV or both. Neate et al. investigated how to draw attention to companion content on a second screen when watching TV [18]. They implemented several stimuli, including an icon shown in the corner of the TV. In a study conducted by Geerts et al. the need for a "do not disturb" mode was shown [8]. However, the researchers mention that users do not want to enable or disable this mode every time they do (not) want to be disturbed.

In summary, notifications are a core feature of current smart devices. They are used to alert to user through multiple modalities. While there is a corpus of work that investigated the use of smart TVs, no standard notification mechanism for smart TVs has been established. What is missing are design guidelines for the design of notifications on smart TVs.

FOCUS GROUPS

We conducted three focus groups to explore the design space of notifications on smart TVs. Each of the focus groups lasted approximately one hour and were held in a meeting room equipped with a white board and projector. We provided post-its and black whiteboard markers, magnets and felt-tip pens (in 3 different colors) as well as printouts of a TV on A4 paper. During the focus groups we provided snacks and beverages. We compensated the participants for their time with 10 EUR. In all groups, one researcher guided the discussion while another researcher took notes and wrote down participants' statements. In the following we first describe the procedure of the focus group which is based on Goodman et al. [9]. Afterwards, we provide information about the participants and their behavior in respect to smart TVs. Then we present results, followed by a summery and a discussion.

Procedure

Each focus group had the same structure and consisted of four parts, an introduction, a round of idea creation, an open discussion and finally a closing discussion with a summary.

Introduction

First, participants were given a short introduction to the topic of the focus group. We prepared slides that explain the current state of notifications on various smart devices, the lack of notifications on smart TVs and how we want to explore them. Furthermore, we encouraged the participants to speak freely during the session with the request to avoid talking at the same time. Afterwards, we asked them to introduce themselves. In the introduction round all participants first stated their names and told the group the kind of devices they own that are able to notify them and the last important notification they can think of. Furthermore, the participants stated whether or not they own a TV and briefly talked about their TV watching behavior.

Idea creation

After the introduction round we asked the participants to imagine a TV that can notify them about events, like messages, emails or calendar reminders. We handed out sheets of paper with a TV printed on them and asked participants to sketch ideas how such a system should look like and how it should behave. We asked them to consider multiple factors including the content, size, position and display duration of notifications. After approximately 10 minutes we asked the participants to discuss their ideas with the person next to them. We instructed them to talk about positive and negative aspects of their ideas and to pick the ideas they like the most.

Open discussion

After the idea creation, we collected all sketches that were selected by the participants and pinned them to a whiteboard. Figure 1 shows one of the focus groups in the discussion phase. We asked the participants to explain their ideas to the rest of the group. Subsequently, we asked the rest of the group about their thoughts on the idea, including the advantages and disadvantages. If not brought up by any of the participants, we asked them how their ideas would work when watching TV alone compared to watching TV with others.

Figure 1. Participants of one of the focus groups discussing their selected ideas on a whiteboard.

Closing discussion and wrap-up

After discussing the ideas of all participants, we explored with the group how far we can go with notifications on TVs. We asked them what they think about showing advertisements, weather forecasts, reminders or product recommendations and openly discussed their concerns and suggestions. This discussion concluded the focus group.

Participants

We recruited students from a university campus to participate in the focus groups. In total 19 students showed interest in participating and we divided those in three groups. The age of the participants was between 21 and 31 years ($M = 25.7$, $SD = 2.8$). The first group consisted of four female and four male participants and was held in English. The second group consisted of six male participants and was held in German. The third group consisted of one female and four male participants and was again held in English.

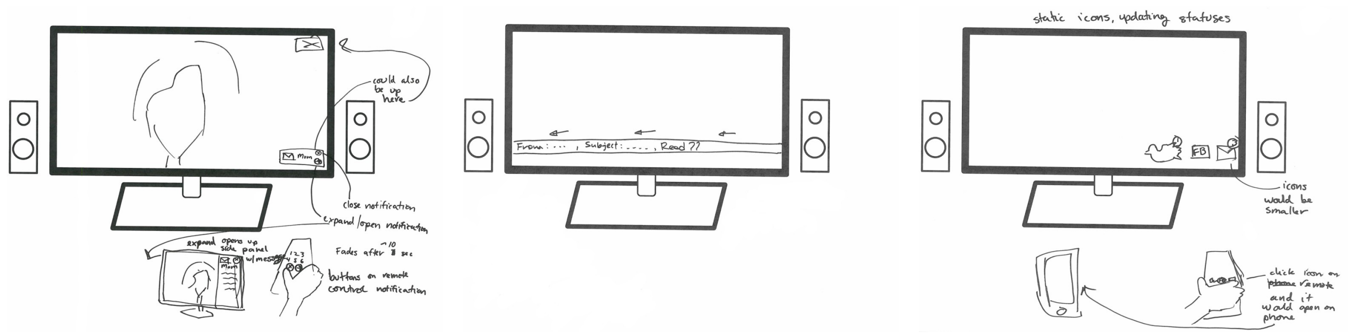
All participants owned a smartphone and either a desktop PC or laptop, or both. Nine (47.37%) participants stated that they own a tablet and ten (52.63%) participants that they own a TV. Streaming was the participants' preferred way to watch movies, series and news. Consuming those streams was not limited to the TV, instead participants also watched them on their tablets and laptops. When asked about the last important notification they received, the participants mentioned email, instant messaging and calendar notifications.

Results

In the following sections we describe the analysis of the idea creation and discussion parts.

Notification styles

To analyze the ideas created by the participants, three researchers went through all sketches and derived factors that distinguish them. Afterwards, they agreed on one set of factors and described each sketch according to these factors. In total we collected 46 sheets of paper, with 37 containing sketches of notification styles and 9 containing written comments. The most popular notification style with 19 sketches was the toast notification style known from desktop and mobile operating



(a) Toast (b) Ticker (c) Icons

Figure 2. Sketches of notification styles created by the participants of the focus groups.

systems (see Figure 2a). Toast notifications overlay parts of the screen and typically consist of a box with an icon and two or more lines of text. On existing operating systems these notifications are typically only shown for a couple of seconds before disappearing again. On some sketches it is mentioned that after a toast notification disappears, a less intrusive indicator should be shown on the screen, e.g. an app icon. In most sketches the toast notifications were placed in the top right or bottom right corners of the screen.

The second most popular suggestion was a news ticker style at the top or bottom of the screen. Variants of the ticker style were found on 6 sketches. Figure 2b shows a sketch of a ticker notification at the bottom of the screen that scrolls the content from the right to the left. While not exactly the same, this style is similar to the notification ticker used in Android prior to version 5.0, which temporarily replaced the status bar at the top of the screen with a ticker that scrolled through the received message content. A concern that came up in the group discussion was that this style would cover subtitles when placed at the bottom of the screen.

Another option that was also suggested 6 times, was to only show icons, similar to the status bar at the top of the screen of Android devices or the system tray area on desktop operating systems. The suggested place for these icons was, similar to the toast notifications, in the top right or bottom right corner. Participants mentioned that the icons could be enhanced by adding a badge to the icons that indicates the number of pending notifications for a certain application. Figure 2c shows three icons in the bottom right of the screen, with badges showing the number of notifications.

The fourth category of suggestions was about embedding a LED in frame or base of the TV. This variant was found 5 times on sketches. Participants suggested that the LED could change the color depending on the app that issued a notification, or depending on the importance of the notification. This option would be similar to notification LEDs found on smartphones.

One participant stated that the TV should be used as smart home hub, showing notifications and other information in full screen when the TV is not in use. Another participant suggested using a screen panel with a wider horizontal resolution that is reserved for notifications. This would allow for a persistent notification stream on the TV without covering content. Independently from the notification style, all participants agreed that sound should be completely optional and configurable. Furthermore, participants agreed that notifications should sync with other devices, thus dismissing them on one device should dismiss them on other devices, too.

Concerns

Participants raised a number of concerns regarding notifications on TVs. A concern was occlusion of content. Notifications should be transparent to a degree, so nothing important is hidden. Examples were subtitles and score boards of sport broadcasts. Participants were concerned about bright pop-ups in an otherwise dark movie.

Another concern that was brought up in every focus group was the difference in watching TV alone in contrast to watching TV with others. The participants disliked the idea of notifications that show the sender and parts of the message while watching TVs with other people. One participant compared this with the scenario of giving a presentation and stated that he is always cautious to disable all notifications when giving a presentation. A "family mode" was suggested that hides the content or disables the notifications completely when watching TV with others. Furthermore, participants stated that notifications should be context aware. First, it should be detected if other people are in front of the TV, so notifications can be adjusted or disabled automatically. Also the idea of too many notifications was regarded as annoying, so only important notifications should be shown. Additionally, notifications should not be shown during truly immersive movies but a summary of missed events after the movie or during slow moments would be acceptable.

In the closing discussion some participants stated that if the notifications were used to display advertisements, they would disable the notifications. Others mentioned that if advertisements would allow them to watch movies or series for free, they consider them acceptable. Recommendation notifications, for example that the successor to the movie that is being watched is currently shown in the cinemas, was considered tolerable, as long as it not overused. The participants agreed that calendar reminders might be useful.

Summary and Discussion

In this section we described the procedure of three focus groups we conducted in order to explore the design space of notifications on smart TVs. The focus groups consisted of four parts, an introduction round, idea creation, open discussion and a closing discussion. In the idea creation part, participants drew sketches of possible notification mechanisms on smart TVs. Categorizing these sketches resulted in four categories for notification styles. The most popular styles were toast notifications, followed by ticker and icon-based notifications. Further variants include embedding LEDs in the TVs frame or base and using the TV as a hub for smart homes. In addition to this visual cues, sound could be used. However, sound should be optional and configurable.

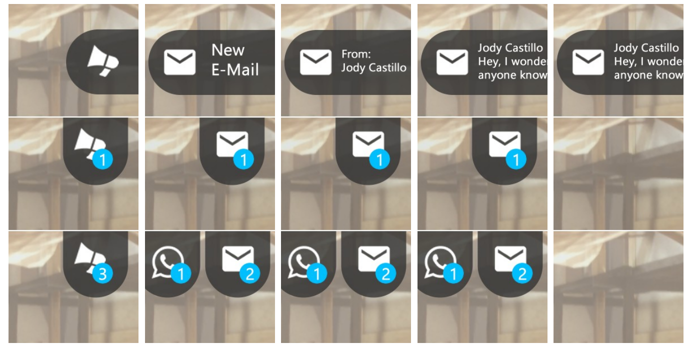
Participants were concerned about privacy aspects of showing notifications on the TV when watching with other peoples. It was suggested to adjust the information shown depending on the number of people in front of the TV. Another concern was occultation of the screen content and distraction caused by notifications. Therefore, notifications should be only used for important events, for example messages from important contacts or calendar reminders.

ONLINE SURVEY

Based on the findings from the focus groups, we further investigated how much content should be shown in notifications on smart TV. To gain results from a wide variety of people we designed an online survey.

Therefore, we created five notification variants with varying amounts of information. The variants are shown in Figure 3. We focused on the amount of information shown rather than the design itself. Because of this, we decided to show all notifications as toast notifications, as this style was the most popular in the focus groups and is common in desktop setups to present notifications. Another preference from the participants of the focus groups was the positioning in the top right or bottom right corner. Accordingly, we displayed all notification variants in the top right corner. Apart from the variants we decided on one scenario. Therefore, we created videos for the five variants. Each video played back the same video content, each video was 25 *sec* long. While the video was playing three notification popped up, the timing was the same for all variants, namely at 4, 15 and 18 seconds after the start. The displayed notification are an email, an instant message and second email notification.

In *Variant 1* a generic notification icon is shown and a badge on the icon keeps track of pending notifications (Figure 3a). *Variant 2* uses app-specific icons instead of the generic icon and the name of the app that created the notification is briefly shown (Figure 3b). *Variant 3* behaves similar to the second variant, however the sender of a message is also shown (Figure 3c). Furthermore, in *Variant 4* an excerpt of the message is shown below the sender, thus showing the most information (Figure 3d). These four variants are persistent until dismissed. *Variant 5* also displays the sender and the message excerpt, however no icon is left behind (Figure 3e).



(a) Variant 1 (b) Variant 2 (c) Variant 3 (d) Variant 4 (e) Variant 5

Figure 3. The five notification variants with varying amounts of content, as shown at 4, 6 and 23 seconds in the video (from top to bottom).

We designed an online survey to receive feedback for the notification variants. The online survey was distributed via mailing lists, social networks and online communities.

Procedure

The online survey was answered by the participants in their web browser and consisted of three parts. First, we asked participants about demographic data, TV watching behavior and devices they are notified on. In the second part all notification variants were rated by the participants. The notification variants were counter-balanced (displayed in random order). For every notification variant a short textual description text was provided along with an embedded YouTube video.

For each condition the participants were asked to rate the following five statements from "Strongly disagree" to "Strongly agree" on a 5-point Likert scale.

(Q1) With this notification mechanism, I have the feeling that I am not missing a notification anymore.

(Q2) This notification mechanism provides me the information that I want.

(Q3) This notification mechanism disturbs my TV-watching-experience.

(Q4) I'd feel comfortable using this notification mechanism when I am watching TV alone.

(Q5) I'd feel comfortable using this notification mechanism when I am watching TV with others.

Finally, the participants should rate the two statements "It is important for me to know how many notifications from each application do I have.". At last the participants could comment our notification variants.

Participants

In total 167 people (50 female, 117 male) completed the survey. They were between 15 and 76 years old ($M = 28.8$, $SD = 10.2$), with 58% being students, 35% employees and 7% others. The online survey was available in English, German and Spanish. The English version was completed 46 (27.54%) times, the German version 105 (62.87%) times and the Spanish version 16 (9.58%) times. The size of the participants' households had a notable variety. 19.7% participants

	$0h$	$< 0.5h$	$0.5-1h$	$1-2h$	$2-3h$	$3-4h$	$> 4h$
Alone	19.1%	26.3%	13.7%	23.3%	10.7%	1.1%	5.3%
Others	26.3%	20.3%	20.9%	19.1%	7.7%	2.3%	2.9%

Table 1. Hours spent per day watching TV alone and with others.

stated that they live alone, 25.1% with another person, 24.5% in a three person household, 22.1% in a four person household and 6.0% live with five or more persons. 2.3% did not state the size of their household.

We asked "How many hours per day on average do you watch TV alone?" and "How many hours per day on average do you watch TV in company with other people?". In Table 1 we present the participants' TV usage.

We also asked the participants what kind of devices they own, on which devices they receive notifications and on which devices they actually read notifications. Possible options were smartphone, tablet, Internet-enabled TV, TV without Internet, desktop PC, laptop, smartwatch, fitness tracker and none. On smartphones, tablets and PCs notifications are a well-known paradigm to receive the attention of the user. Current smartwachtes and fitness trackers often connect to a smartphone. Figure 4 shows the responses. 95.81% own a smartphone, 57.49% a tablet, 51.50% a TV with an Internet connection, 40.72% a TV without an Internet connection, 61.08% a desktop PC, 90.42% a laptop, 14.97% a smartwatch and 11.38% a fitness tracker. One participant stated that he does not own any of these devices. Generally, participants receive and read notifications on all smart devices with smart TVs being a notable exception.

Results

We analyzed all subjective ratings of the five conditions (Figure 5) using a Friedman test. We also analyzed the ratings for each rating using the Friedman test and Wilcoxon signed-rank post hoc tests with an applied Bonferroni correction, resulting in a significance level of $p < 0.005$.

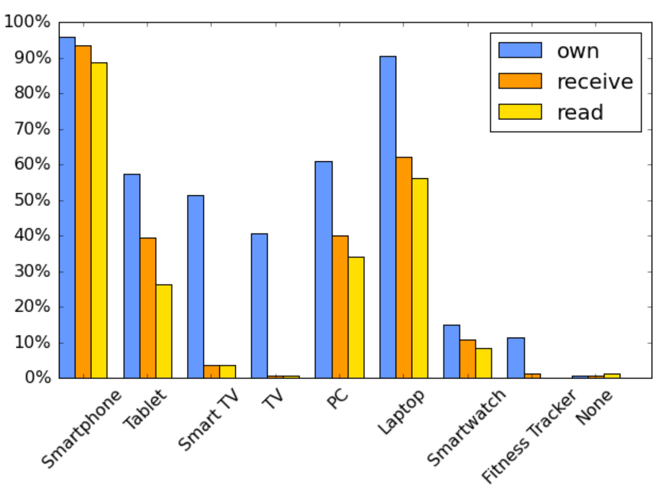


Figure 4. Devices which participants of the online survey own, receive notifications and read notifications.

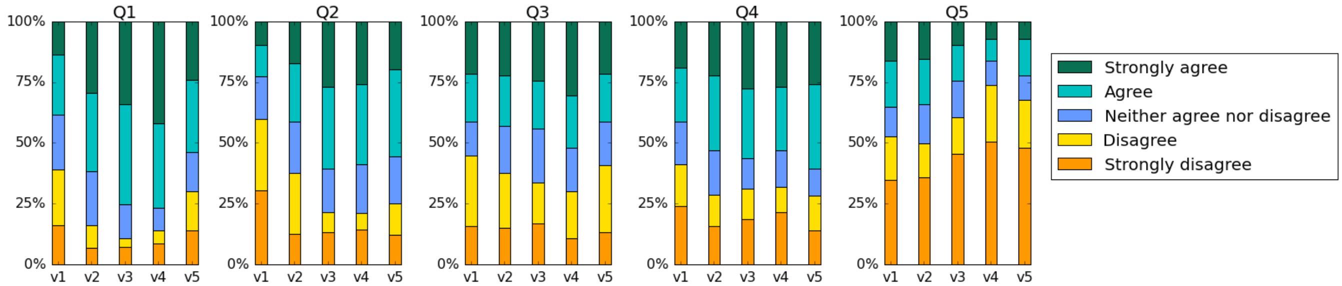
(Q1) Not missing notifications: We found a significant difference for Q1, $\chi^2(4) = 115.020$, $p < .001$. For this statement Variant 3 ($M = 4.40$, $SD = 1.08$) and Variant 4 ($M = 4.40$, $SD = 1.13$) received the highest ratings, followed by Variant 2 ($M = 4.07$, $SD = 1.22$), Variant 5 ($M = 3.78$, $SD = 1.36$) and Variant 1 ($M = 3.38$, $SD = 1.34$). The rating of the variant with the generic icon is significantly lower than all other variants (1vs2 $Z = -6.322$, $p < .001$, 1vs3 $Z = -7.436$, $p < .001$, 1vs4 $Z = -7.436$, $p < .001$, 1vs5 $Z = -2.860$, $p = .004$). Variant 5 is significantly lower rated than Variant 3 ($Z = -5.326$, $p < .001$) and Variant 4 ($Z = -5.464$, $p < .001$).

(Q2) Provides wanted information: We found a significant difference for Q2, $\chi^2(4) = 123.015$, $p < .001$. For this statement Variant 3 ($M = 3.99$, $SD = 1.29$) received the highest rating, followed by Variant 4 ($M = 3.96$, $SD = 1.28$), Variant 5 ($M = 3.86$, $SD = 1.32$), Variant 2 ($M = 3.45$, $SD = 1.36$) and Variant 1 ($M = 2.86$, $SD = 1.22$). Again, Variant 1 received a significantly lower rating all other variants (1vs2 $Z = -5.798$, $p < .001$, 1vs3 $Z = -7.922$, $p < .001$, 1vs4 $Z = -7.022$, $p < .001$, 1vs5 $Z = -6.953$, $p < .001$). Also, Variant 2 (app icons, no text) received a significantly lower rating than variants with text, namely Variant 3 ($Z = -4.325$, $p < .001$) and Variant 4 ($Z = -3.409$, $p = .001$).

(Q3) Disturbs TV experience: We found a significant difference for Q3, $\chi^2(4) = 17.560$, $p < .001$. For this statement Variant 4 received the highest disturbance rating ($M = 3.74$, $SD = 1.36$), followed by Variant 3 ($M = 3.56$, $SD = 1.35$), Variant 2 ($M = 3.49$, $SD = 1.37$), Variant 5 ($M = 3.42$, $SD = 1.38$) and Variant 1 ($M = 3.38$, $SD = 1.40$). Variant 1, which displays only a generic icon, received the lowest disturbance rating.Variant 4, with sender and message excerpt, was rated significantly more disturbing than all other variants (5vs4 $Z = -3.533$, $p < .001$, 2vs4 $Z = -3.073$, $p = .002$, 3vs4 $Z = -3.018$, $p = .003$, 1vs4 $Z = -3.751$, $p < .001$).

(Q4) Comfort alone: We found a significant difference for Q4, $\chi^2(4) = 22.216$, $p < .001$. For this statement Variant 5 received the highest rating ($M = 3.93$, $SD = 1.36$), followed by Variant 3 ($M = 3.81$, $SD = 1.38$), Variant 2 ($M = 3.78$, $SD = 1.35$), Variant 4 ($M = 3.75$, $SD = 1.37$) and Variant 1 ($M = 3.41$, $SD = 1.38$). Variant 2-5 are not significantly different. Variant 1 has a significantly lower rating than Variant 2 ($Z = -3.398$, $p < .001$), Variant 3 ($Z = -3.654$, $p < .001$) and Variant 5 ($Z = -4.014$, $p < .001$).

(Q5) Comfort with others: We found a significant difference for Q4, $\chi^2(4) = 60.511$, $p < .001$. For this statement Variant 2 received the highest rating ($M = 3.19$, $SD = 1.36$), followed by Variant 1 ($M = 3.18$, $SD = 1.39$), Variant 3 ($M = 2.89$, $SD = 1.26$), Variant 5 ($M = 2.77$, $SD = 1.23$) and Variant 4 ($M = 2.59$, $SD = 1.10$). Variant 2 is significantly different to all variants except Variant 1 (2vs3 $Z = -3.415$, $p = .001$, 2vs5 $Z = -4.108$, $p < .001$, 2vs4 $Z = -5.236$, $p < .001$). Variant 1 is significantly different to Variant 3 ($Z = -3.059$, $p = .002$), Variant 5 ($Z = -4.127$, $p < .001$) and Variant 4 ($Z = -5.008$, $p < .001$). Also, Variant 3 is significantly different to Variant 4 ($Z = -3.636$, $p < .001$).



(a) (b) (c) (d) (e)

Figure 5. Ratings of the five statements (Q1-5) of the online survey for each notification variant (v1-5).

Optional comments

The last part of the online survey included a free text field that allowed the participants to enter a comment independent of the previous tasks. Two researchers translated comments written in Spanish and German to English and filtered comments without usable feedback. This resulted in 55 comments that were subsequently categorized by their content.

Thirteen participants explicitly stated that they would not use a notification system on their TV under any circumstances. Two participants stated that they do not want to be disturbed when watching TV at all and thus silence their smartphones. Three other participants were not as opposed to receive notification on the TV. Instead, they stated that it depends on the importance of the notification, which in return depends on the urgency or person sending the message. An interesting category of comments from 7 participants distinguished between watching a movie and "entertainment programs", for example quiz shows "where you do not have to actively focus on the program to follow it" *(Translated from German.)*. Two participants suggested displaying notifications after a movie.

In the survey we asked the participants how comfortable they would feel using this notification style alone compared to using it when other people are around. In the free text field 5 participants addressed this issue. They suggested multiple modes that can be switched depending on how many people are around. One mode would display notifications without restrictions, whereas the "private" mode would only display notification hints. Customization is another topic that was addressed by 13 participants. They suggested changes to the notification shown in the videos and overall options they would like to see, from the color of the notification to the screen corner that should be used.

Summary and Discussion

In this section we described the online survey, where we evaluated five notification variants with a varying amount of content. For each notification variant, we asked participants to rate their agreement to five statements and asked them what they like and dislike. Furthermore, we asked them in a free text field to give us general feedback to notifications on smart TVs. The participants owned a number of smart devices, on which they receive and read notifications. However, an exception to this poses are TVs and smart TVs on which most participants did not receive or read notifications.

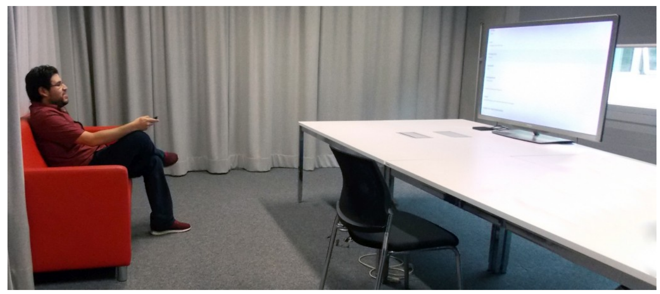


Figure 6. The setup for the lab study. A participant is customizing the notification toast on the TV using a remote.

The results of the online survey indicate participants prefer to see the sender or the sender in addition to a message excerpt in the notification. Participants are concerned about missing notifications if no indicator is left behind and showing only a generic icon is not enough information for the participants. However, persistent indicators and showing more text in the notification increases the occluded display space. Therefore the participants stated that the variants with text disturb the TV watching experience the most. Four of our tested variants left an icon behind and not doing that could decrease the disturbance created by the text. When watching alone, participants liked all variants except the generic app icon. When watching with others, participants liked the variants that show the sender or message less.

LAB STUDY

In the online survey we investigated the amount of content which should be shown in notifications on smart TVs. One major result is that notifications should be customizable by the user. To further investigate in this direction, we conducted a lab study where participants had the task to customize a toast notification. Therefore, we set up a room in our lab with a sofa and a TV (see Figure 6). We implemented an application which enables us to push notifications to the TV while a video is playing. Derived by the results from the online survey there is a need to investigate in the customization while watching alone and with others. Therefore, we conducted the lab study with two groups, one group watching alone and the other watching together with a second unknown person. This was done to see if participants choose different settings. In the following we describe the study as well as the results.

Design

To get insights into the differences between watching television alone and with other people, we ran the study in a between subjects design. The participants of one group (A) sat alone in front of the TV, while the second group (B) watched a video in presence of a researcher. We used a 55” Philips Full HD TV connected to an Amazon Fire TV box to achieve a realistic TV experience. The Amazon Fire TV enabled us to push notifications on top of a video and also enabled the participant to customize them. Another limitation of the online survey was that we created an exemplary scenario, resulting in notifications that were not meaningful for the participants. Therefore, we developed a smartphone application for Android devices to log all notifications shown on the device. All notifications shown in the lab study were therefore notifications the participants recently received. The notifications were selected randomly from the log files and varied from instant messaging notifications to system messages.

For the lab study itself we developed a second Android application that was installed on the Amazon Fire TV. This app is capable of playing back a video while showing a overlay with a notification. Furthermore, it allows the user to control the representation of the notification with nine different settings. The GUI of the settings menu is shown on the left side in Figure 7. These settings are: position, size, icon, theme, opacity, duration, content, lines and sound. The *position* setting controls where notifications appear on the screen, with nine possible options from the top left to the bottom right. The *size* setting allows to scale the notification from small (225dp), medium (300dp) to large (375dp), using Android’s density-independent pixels (dp) metric. The *icon* setting allows to show the icon of the app in full color and gray scale, a generic-app icon in color and gray scale, or no icon at all. The *theme* setting allows to set the background of the notification to white (light theme) or black (dark theme). The *opacity* allows to set the opacity to 25%, 50%, 75% or 100%. The *duration* setting controls how long the notification is shown, from 1 second to 25 seconds. The *content* setting controls how much of the logged text is shown. Possible options are to only show the name of the app, to include the title/sender, and to show title/sender and message. The *lines* setting depends on the content setting, because it controls how many lines are shown, with possible values being 1-5 or unlimited. The *sound* setting can be either enabled or disabled, and plays a default sound when enabled.

Procedure

We invited the participants two times. The first time to sign a consent form and to set up the notification logger. Two days later we invited them the second time to our lab. First, we asked them to fill in a demographic data form and seated them on a sofa in front of the TV ($3m$ between screen and participant). Then we explained that we built an application for the TV that would display random notifications from the past two days while an episode of the series “Big Bang Theory” was playing. For group A it was explicitly stated that they would watch the episode alone, without anyone in the room. For group B it was stated the researcher would stay in the room. We opened the settings screen and briefly introduced the participants to the nine available settings. At this point no setting was configured yet. Therefore, the participants were asked to explore the settings by themselves. After configuring all settings, a preview notification appeared that allowed the participants to make further adjustments. When participants decided that the notification’s representation was appropriate, we started the first half of the episode. For group A the researcher left the room. Ten notifications were shown at predefined times. The predefined times for displaying notifications were randomly chosen by us and the same for each participant. After the first half finished, the episode was paused and the settings page was opened automatically. The participants had the opportunity to change their settings for the second half of the episode. In the second half ten additional notifications were shown. After watching the full episode, the settings page opened again and participants were asked to adjust the settings one more time. Finally, we asked participants to rate the importance of each setting on a 5-point Likert scale.

Participants

In total 14 participants (5 female) took part in the study all were recruited on our university’s campus. They were between 22 and 32 years old ($M = 25.86$, $SD = 2.95$). Twelve of the participants were students, one participant was a PhD student, one participant was a promoter.

Results

In Figure 8 the agreement to the importance of the settings is shown, highlighting the need for customization of notifications. The three most important settings to customize the notifications were the *position* ($M = 4.79$, $SD = 0.43$), *size* ($M = 4.71$, $SD = 0.47$) and *content* ($M = 4.50$, $SD = 0.65$). Followed by *duration* ($M = 4.29$, $SD = 0.83$), *lines* ($M = 4.01$, $SD = 0.62$), *opacity* ($M = 3.93$, $SD = 1.14$), *icon style* ($M = 3.64$, $SD = 0.84$) and *sound* ($M = 3.50$, $SD = 1.83$). The *theme* setting received neutral ratings ($M = 3.00$, $SD = 1.24$). However, statistics did not reveal any significant difference between people, who watched alone or together with other people.

Derived from the participants’ final settings the following values are the most popular. For the nominal setting values we will report the *modus* and for the duration as a scale we report *M* and *SD*. This results in a *most popular* notification style, which is represented as follows: The notification is in a dark themed box in the upper right corner displayed for $M = 4.93$, $SD = 2.6$ seconds with 75% opacity. Including a colored app icon, the sender and two/three/unlimited lines of the message, with a small font and no sound. The visual representation is shown on the right side of Figure 7.

Position: Nine participants preferred the position in the upper right corner, two participants chose the bottom left corner and another two participants chose the bottom right corner. There are no significant differences between both groups. It is important that notifications are positioned in a way that provides visibility, but also does not hide the content or program inserts [P4, P8]. Two participants argued, that they chose the position because they are used to it from their smartphones and laptops [P11, P12].

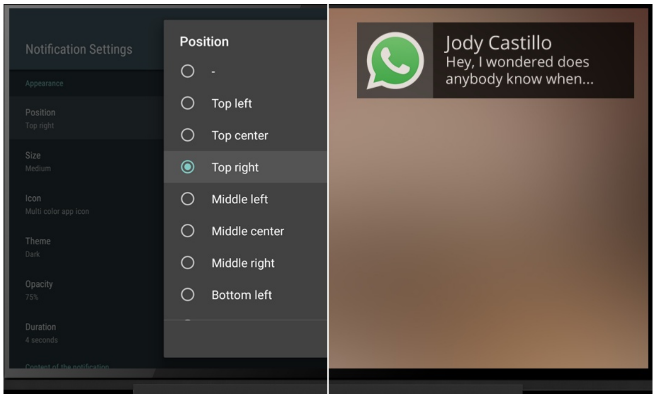


Figure 7. The study app on the Amazon Fire TV. The left side shows the settings with the *position* options dialog. The right side shows an exemplary *WhatsApp* notification with the *most popular* settings.

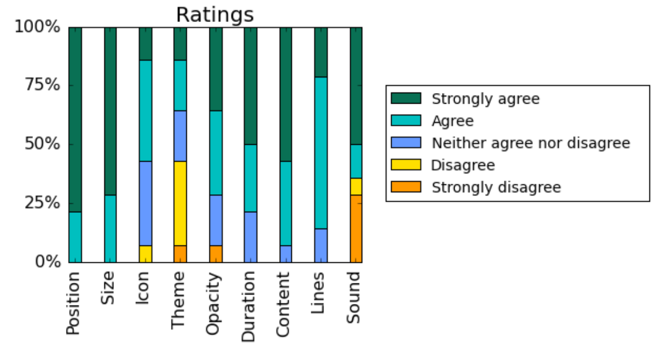


Figure 8. The importance ratings for the nine different settings we investigated in the lab study.

Size: Ten participants chose a small representation of the notification, 4 the medium size and none the large size. There are no significant difference between both groups. The notifications should be big enough to read and small enough to not hide the content [P8]. Too big overlays are annoying [P4, P14] and the size should depend on the TV's size and the distance to TV, too [P2].

Icon: The selection of the used icon depends on the two groups. Participants, who watched together with a researcher have chosen an icon, which belongs to the incoming notification. The app icon in color was chosen by 5 participants and 2 participants used the app application icon in gray scale. Participants, who watched alone chose dissimilar icons. Only 3 participants chose the app icon in color. Two participants used a generic icon for an incoming notification and two others decided to hide the icon completely. The usage of an application icon helps to the judge importance of the notification, which generated the notification [P1, P3, P9, P10, P11].

Theme: Ten participants set the dark variant and four the light one. Two participants mentioned that the contrast is important [P1, P4] and two other participants think there is not much of a difference between the light and the dark theme [P9, P12].

Opacity: Participants who watched alone all chose a high opacity, 6 of them used the 75% opacity and 1 participant used the 100% opacity. From the participants who watched together with a researcher, one chose 25% opacity and two participants chose 50%, 75%, and 100% respectively. The notification should not block the TV content [P8, P12] and not be too transparent [P3, P12]. This setting is important for minimal distraction [P11]. One participant thinks an opacity with 25% or 50% is too transparent [P3], while another participant said the opacity should be between 25% and 50% to not block the TV content [P8].

Duration: Participants who watched alone chose longer durations for displaying the notifications. One participant used a duration of 3 *sec*, one participant used a duration of 4 *sec*, 4 participants used a duration of 5 *sec* and one participant chose a duration of 13 *sec*. However, 2 of the participants who watched together with a researcher chose a duration of 3 *sec*, 2 participants used 4 *sec* for the duration and 3 participants chose a duration of 5 *sec*. The setting for the duration of displaying the notification is a balance between being long enough to read the message and short enough so the notification is not a nuisance [P11]. The opinions to the duration diverges, too. One participant who watched alone thinks, more than 10 *sec* are too much for displaying the notification [P3]. However, a participant who watched with a researcher commented $2-3$ *sec* are enough for displaying the notification [P8]. Another participant prefers that there should be a standard duration and user can terminate to read or skip by pressing a button [P2].

Content: From the participants who watched alone 1 participant chose to display the sender only, 6 of them chose to display the sender and the message of the notification. For the participants who watched together with a researcher 4 participants chose to display only the sender and 3 of them chose to display the sender and message of the notification. No one of the participants chose the option to display only the name of the application. The participants said that is important to decide what should be displayed on the screen because of privacy issues [P1, P8, P12]. There will be some people who want to read the notification only on their phone [P2], but other people might want to read the notification on the TV [P2]. When more text is displayed, longer attention is required and so you could miss what you are watching [P9] but also affects to what extend you are informed [P10].

Lines: From the nine participants who chose to display the message of their notifications, three chose two, three and unlimited lines of text respectively. These include participants who watched together with a researcher, one of them chose 2 rows and two others 3 rows for the message. The length of the displayed content is a privacy setting as well and depends on who could see the notification [P8, P10]. Another participant suggested a meaningful reduction of the displayed content, when full text is too much for a short insert [P4].

Sound: All participants but one disabled the sound for an incoming notification. They argue that the sound makes no sense [P1], is not necessary [P2] and distracting [P11]. Three participants perceived the sound as annoying [P4, P10, P12]. One participant thinks that the sound might bother some people but might help to remember acting on the notification after watching TV [P9].

Summary and Discussion

In this section we described our lab study, where we invited 14 participants to customize notifications while watching TV. The lab study revealed a clear need for customization. Participants rated the importance for all settings on average at least to *neither agree nor disagree*. We also reported qualitative feedback regarding the provided settings. Furthermore, we presented the *most popular* configuration of settings which can be used as an initial setting for further studies. One limitation of the "watching with a researcher" approach is the relationship between the participant and the researcher. In future studies differences between watching with friends, family or the partner should be investigated.

DESIGN GUIDELINES

Based on our findings from the focus groups, the online survey, and the controlled lab study we derived the following guidelines for notifications on TVs. The guidelines can be used by developers to gain the user's attention on smart TVs in a meaningful way.

Evaluate the importance

Developers should evaluate the importance of notifications instead of creating a stream of notifications as it is currently the case on other smart devices. Related work on smartphone notifications has shown that important notifications are about people and events [21]. Insights gained in the focus groups and the online survey confirmed this. For some people nothing is important enough to distract them from their immersion when watching TV. Because of this, notifications on smart TVs should always be optional.

Privacy considerations

Privacy aspects on smart TVs differ from other smart devices. TVs are typically shared devices and are used by multiple people, often at the same time. Unlike other smart devices it is therefore not recommended to simply display message excerpts in notifications. An idea brought up in the focus group was using multiple profiles depending on how many people are in front of the TV. One profile could be used for watching TV alone with no restrictions to the displayed information. Another profile could be used when watching TV with others. In this "private" profile, notifications could show various levels of information. For example, not showing the message excerpts, excluding the sender or using a default application icon. We suggest a system that detects people in front of the TV and uses this knowledge to automatically adjust the amount of information shown in the notifications. If an automated solution is not possible, it should be at least possible to switch between a public and private mode with ease.

Time interruptions

Multiple participants of the online survey mentioned that they like the idea of notifications on the TV. However, the notifications should not be shown during movies, as this was regarded as distractive. Instead, participants suggested to show notifications after a movie. Previous work on timing notifications has shown that notifications are less distractive if they are shown in between tasks [1]. Apart from the end of a movie we suggest notifying the user during advertisement breaks and, in the case of video on demand movies, when the movie is paused.

Be subtle

Notifications on smart TVs should be subtle. Effects and animations should be used with care to avoid distracting the user. Participants of our lab study disliked the idea of playing a sound. The size, opacity, display duration and text length have to be balanced in order to maximize readability and minimize occlusion of the content.

Allow customization

In all studies participants agreed that it must be possible to customize how notifications are displayed. As stated above, the amount of information to be displayed should be customizable. Furthermore, the position of the notification and display duration on the screen is something that participants were not in agreement, thus should be configurable.

CONCLUSION AND FUTURE WORK

In this paper we developed guidelines for notifications on smart TVs. Through a set of three focus groups we collected insights about users' attitude towards notifications on TVs. The design space includes the presentation of notifications, the displayed content, the application causing the notification, the number of received notifications, and how long a notification stays on the screen. We further studied selected design alternatives in an online survey to get more information about the displayed content of notifications on smart TVs. With these findings we implemented an application which enables us to display notifications on the TV while a video is playing and conducted a lab study. In the lab study we investigated the difference in the settings between watching alone and watching together with other people. From the findings, we have elaborated our design guidelines for displaying notifications on a TV. Only notifications truly important for the user should be shown. Furthermore, users' privacy should be considered especially if multiple people share the TV. Notifications could mainly be shown during breaks and be presented in a subtle way. Finally, users should be enabled to easily customize the presentation.

In the future, further insights could be gained by implementing a system that shows notifications on smart TVs and conducting a field study by installing the system in peoples' living rooms. In particular, it would be interesting to use a system that is able to determine the number of viewers, for example through the use of depth sensing cameras. The system could adjust the settings and types of notifications shown according to the viewers. Furthermore, means to interact with notifications shown on smart TVs should be investigated. Important notifications often inform about messages and users therefore might expect that they can directly react to them using the smart TV. A further direction are ambient visualizations that display notifications in a subtle way. A potential approach is to use technologies such as Ambilight and IllumiRoom [13] that allow visualizations in the surrounding of the TV.

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