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Usability Evaluation of a New Text Input Method for Smart TVs

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Abstract

Smart TVs are becoming an increasingly important multimedia device for home entertainment. A smart TV is a platform that provides access to many types of media and services such as games, the Internet, social networking sites, and TV programs. One of the most important interactions between users and these platforms is the ability to effectively enter and edit text. The purpose of this study was to test a new approach for smart TV text entry that combines a touch pad and virtual keyboard interaction. A prototype was created and tested against existing methods (a simple remote control, a touch pad, and a physical keyboard). Twenty college students were recruited to perform a usability test with each of the four different input methods. Participants performed a text entry task and a text edit task on each device. The results indicate that combining a virtual keyboard with touch pad type functionality for text entry and editing can lead to faster text entry and faster text editing.

Keywords

smart TV, input method, user experience, usability

Introduction

Smart TVs are increasingly becoming important multimedia devices for home entertainment (Jeong & Lee, 2014). A smart TV combines a CPU and operating system in a set-top box or display to integrate TV broadcasts, Internet, applications, and other services (Jeong & Lee, 2014). Video and media are increasingly being consumed from many different sources. Video content may come from broadcast TV, physical media (such as DVDs), or from online Internet sources—a smart TV can provide access to view them all (Gritton, 2013).

A smart TV can be used for more than video; it can be used for playing games, browsing the Internet and social networking sites, or using one of the many different applications and services that can be installed. (Boztas, Riethoven, & Roeloffs, 2015). This ability to perform more general purpose, open-ended tasks is changing the way that users interact with a TV. In the past one may have only needed basic controls such as power, volume, or channel selection; now, however, a smart TV is no longer a single function device with static capabilities and defined requirements for input. With the capability to perform more general tasks, one of the most important user interactions is typing and editing text (Sporka, Poláček, & Slavík, 2012). Depending on the apps used, a user may need to, for example, enter account credentials, enter search keywords, or write text for forums or social media.

Entering and editing text for any of these cases with smart TVs is currently challenging (Geleijnse, Aliakseyeu, & Sarroukh, 2009) and has a significant negative impact on the user experience (Barrero, Melendi, Pañeda, García, & Cabrero, 2014). This limitation also has been a barrier to innovation and has slowed down the development of using smart TVs as a platform (Gritton, 2013).

Current Text Input Methods for Smart TVs

The most common input device used in nearly all smart TV platforms is the remote control (Geleijnse et al., 2009; Pedrosa, Martins, Melo, & Teixeira, 2011). A number of the following different input methods have been used by these remote controls (see Figure 1 for an illustration):

- Most of the current text input is done through the use of an on-screen keyboard as the main text entry method. Different keys on the screen are selected by using an arrow pad on the remote control. A button on the remote is used to select the highlighted key on the screen (Figure 1a).
- Another method utilizes an on-screen keyboard to enter text. Different keys on the screen are selected by using a touch pad interface on the remote to select the desired key on the screen (Tarr, 2014; Figure 1b).
- A physical keyboard is another method offered by some third party device manufacturers. It consists of a computer-like keyboard that has a wireless connection to the TV. Text is typed or edited using the physical buttons on the keyboard. On-screen cursors are moved using arrow keys on the keyboard (Vega-Oliveros, Pedrosa, Pimentel, & de Mattos Fortes, 2010; Figure 1c).
- A virtual keyboard on a mobile device is another approach that has been used. An application that connects to the TV is installed on a mobile device. The application provides a keyboard interface on the touch screen of the mobile device. Operation is similar to the physical keyboard except that text is entered through the application's keyboard (McCracken, 2014; Figure 1d).
- Speech input has also been used. With this method, the TV employs speech recognition. Users control the interface through commands that are spoken out loud. Text is entered through normal speech. Long sentences can be difficult to enter, and the speech-to-text editing (such as if a word is not recognized correctly) is problematic. Users can use the voice search button on the remote control to input text (Igarashi & Hughes, 2001; Figure 1e).

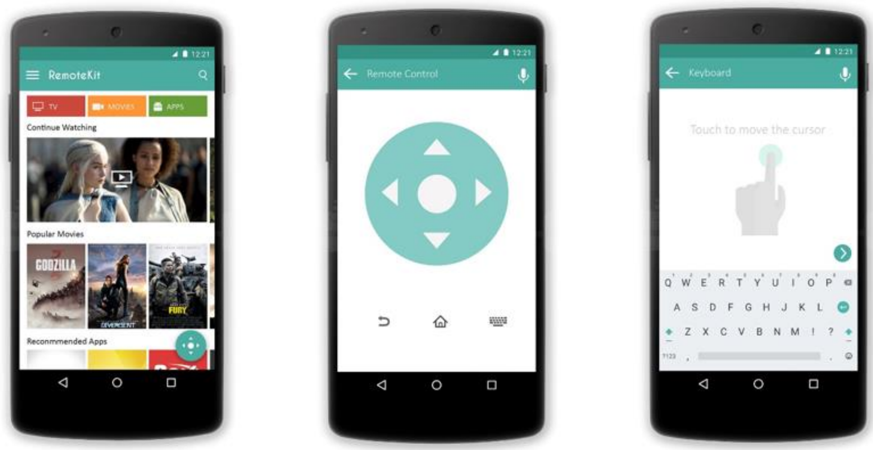
Figure 1. Graphics showing concepts of different text entry and edit methods for smart TVs. From left to right: (a) arrow buttons on remote control with an on-screen keyboard, (b) touch pad on the remote control with an on-screen keyboard, (c) physical keyboard, (d) smart device virtual keyboard, (e) voice input.

Each input method has different pros and cons. Iatrino and Modeo (2006) found when typing text, using a physical keyboard is preferred to arrow buttons on a remote control with an on-screen virtual keyboard. Using remote control arrow pads to select keys can lead to other problems. Some interfaces do not allow users to move the cursor within already entered text. To edit a typo in this case, all characters entered up to the error must be deleted and re-entered after the mistake has been corrected. Touch pad based interfaces often avoid this issue by allowing the cursor to be easily positioned within a block of entered text by simply moving a finger on the touch pad. Other research has shown that current smartphone virtual keyboards are very flexible and make it easy for users to switch between different keyboard types, such as number, symbol, emoji, different languages, and so on (Wu, Huang, & Wu, 2013). Smartphone keyboards also have the advantage in that users are familiar with the interface. However these keyboards do not provide an efficient mechanism for editing text (Pedrosa et al., 2011).

The Design and Development of a New Method

In this study a new text entry method for a smart TV is proposed and evaluated. The goal of the design was to improve text input efficiency (faster task completion) and to provide a better end user experience. The approach for the design was to combine the typing advantage of a mobile device’s virtual keyboard with the editing advantage of a touch pad.

A functional prototype was developed for user testing in this study (see Figure 2). The app consisted of a home screen with navigation to various functions. The app allows interaction with the TV via an arrow pad. The app also enabled an alternate interface developed for the study. This interface enabled on screen navigation via a trackpad-like touch control on the top part of the screen (see Figure 2c). This allowed users to place the cursor anywhere within a text field to allow specific edits to be made. A rounded button in the touch pad area was provided as a shortcut to automatically move the cursor to the end of a sentence. A virtual keyboard for text entry was provided at the bottom of the screen. Key presses on this keyboard utilized lift-off activation (the key is selected when the finger is lifted off of the touch screen). The mobile application ran on an Android based Google Nexus 5 smartphone. All typing, touch, and other data was sent to a Windows laptop via Wi-Fi and then to the TV via HDMI.



(a) (b) (c)

Figure 2. Prototype of the mobile app user interface for text entry and text editing on smart TVs. From left to right: (a) home screen, showing all features of this app; (b) remote control function that includes keyboards (keyboard buttons) and traditional controls; (c) the core function for text entry and editing that combines touch gestures (top blank area) and the smartphone virtual keyboard (bottom area)

Method

This study evaluated the effects of the new design on text entry and editing on a smart TV compared to currently available methods. Twenty college students aged 18 or over were recruited to participate. All participants had at least one year of experience using smartphones or TVs (either smart or not).

Each participant completed a usability test using the following four different TV input devices corresponding to a different text entry and input method:

- Input Method 1 (Figure 3): A remote control that utilized a direction pad (up, down, left, right, and OK button) to select keys on a virtual on-screen keyboard to input or edit text. An Amazon Fire TV set-top box was used as it utilizes this method of input.
- Input Method 2 (Figure 4): A touch pad app that allowed participants to move their finger on the touch pad to select the keys on a virtual keyboard on the TV screen to input or edit text.
- Input Method 3 (Figure 5): A physical wireless keyboard that allowed participants to enter or edit text on the TV by typing on the keyboard. The Rii Mini Wireless Keyboard was used to represent this input method.
- Input Method 4 (Figure 6): Utilized the new keyboard/touch pad smartphone application developed for this study that allowed
    - a touch pad control on a mobile phone screen to control the movement of the cursor on the TV interface;
    - the ability to select, copy, and paste text on the TV interface via the touch pad; and
    - the ability to switch between different keyboards (text and numbers) via a swipe gesture on the touch pad area.

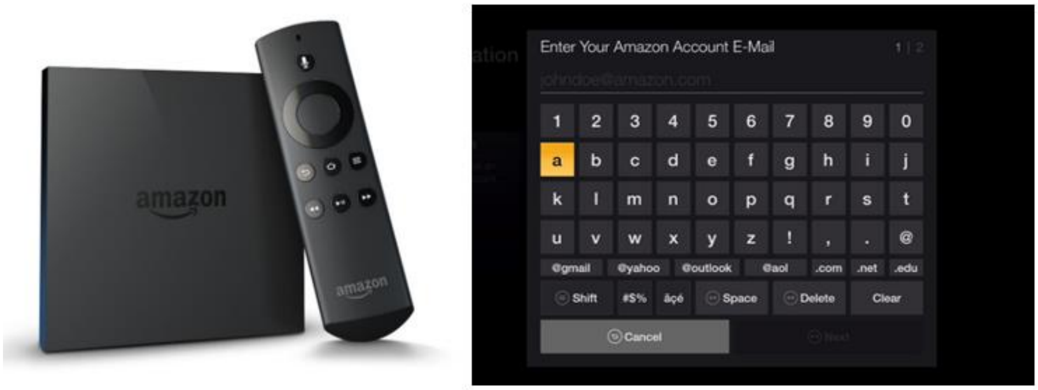


Figure 3. Amazon Fire TV set-top box with a traditional remote control and on-screen keyboard.

Figure 4. The touch pad app (left) that allows users to select keys on an on-screen keyboard (right) to enter text.

Figure 5. Rii Mini Wireless Keyboard.

The study setup (Figure 6) included a 50-inch LG television that could support all of the text entry devices used. Additional equipment used included a laptop for exchanging data between the TV and new smartphone app, a Google Nexus 5 smartphone on which to run the app, and an iPad to record task times

Figure 6. The LG TV setup in the space used during the study.

Procedure

Before beginning the usability tests, participants completed a pre-test questionnaire to gather information about their previous experience with smart TVs and smartphones. Participants also completed a brief training task with each input device in order to become familiar with each one.

The usability tests were organized in two sessions for each participant. In the first session participants completed a text entry task with each of the four input devices that corresponded to the four text entry/edit methods. In the second session the participants completed a text edit task with each of the four devices. The sessions were conducted back to back with each participant completing the text entry task first.

In Session 1, participants were given a text entry task. This sentence included letters, numbers, and symbols:

> Game of Thrones is an American series created for HBO by David. Contact: David083@gmail.com; #394-209-9275

The text was entered using each of the four input methods. The order of the devices used for the text entry task was randomized for each participant. Participants were instructed to finish each task as fast and correctly as possible. The total time taken to enter the text was measured. Participants completed a NASA Task Load Index (TLX) form (Hart, 2006) and a System Usability Scale (SUS) form (Brooke, 1996) immediately after completing the text entry task with each input method.

In Session 2 participants were given a text editing task. The following pre-entered text (containing letters, numbers, and symbols) was presented on the TV interface:

> Game of Thrones is an American series created for HBO by David. Contact: David083@gmail.com; #394-209-9275

Participants were instructed to edit the entry so that it read as follows:

> Game of Thrones is a fantasy drama created for HBO by Dave. Contact:Dave083@gmail.com; #394-259-9275

The text edits were made using each of the four entry methods. The order of the devices used for the text editing task was randomized for each participant. Participants were not allowed to clear and re-enter the whole sentence but had to correct certain letters, numbers, and symbols in the sentence. The total time needed to make the corrections was measured. Participants again completed the NASA TLX form and a SUS form immediately after completing the text editing task with each method.

After completing all of the study activities, participants completed a Session Overall Review form to evaluate different text entry and edit methods for smart TVs.

Measures and Analysis

The NASA TLX is an instrument that measures a person's subjective workload in performing a task. It consists of six subscales corresponding to mental demand, physical demand, temporal demand, performance, effort, and frustration level. Each scale is scored on a range from 0 (low) to 100 (high). The combination of these subscales are representative of the overall workload experienced by most people performing most tasks. The NASA TLX includes a weighting scheme that allows it to account for factors that are unique to an individual or task. The weighting makes TLX more difficult to apply so it is common to simply use the unweighted responses to the subscales, referred to as a Raw TLX (RTLX) score (Hart, 2006).

The SUS is a 10-item Likert scale survey that is scored on a scale of 1 (strongly disagree) to 5 (strongly agree). A SUS score is a single number that represents a composite measure of the overall usability of a system that is being studied. A SUS score is calculated by taking the answers to the odd items on the survey, subtracting 1 from the Likert value provided by a participant and then summed. Even items on the survey are scored by taking 5 minus the Likert value provided by a participant and then summed. The sums for the even and odd items are added and then multiplied by 2.5 (Brooke, 1996). SUS scores can range from 0 to 100.

The overall review form was a four question survey that asked users to rate each of the input devices and methods based on their experience with entering or editing text during the study. The rating was on a scale of 1 (worst) to 10 (best).

One-way ANOVA and Turkey post hoc tests were performed on the collected data.

Results

The following sections present the analysis of the data collected from the pre-test questionnaire, the text entry task, and text editing task.

Pre-Test Questionnaire Data

The participants had an average 5.6 years of experience using smartphones. Fifty percent of the participants had used a smart TV in the past and only 35% reported experience with trying to enter text.

Session 1: Text Entry Task Data

The data from Session 1 included the time each participant spent completing a task and the participants' post-test questionnaires, the RAW TLX, the SUS, and the Overall Review.

Task Completion Time

A one-way ANOVA (Completion Time by Device) was applied to the data. There were statistically significant differences between group means as determined by the one-way ANOVA ($F = 157.446$, $p < 0.001$). Next, post hoc tests were run to confirm where the differences occurred between groups. The results show there were significant differences between the new design (Device 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p < 0.001$). There was no significant difference between the new design and the physical keyboard (Device 3; $p = 0.572$) or between the remote control and the touch pad ($p = 0.094$).

Table 1. Completion Time With Each of the Four Devices in Session 1

Device	**Mean**	**Std. deviation**	**Std. error**	**95% confidence interval for mean**	
				Lower bound	**Upper bound**
Remote control	329.25	48.01	10.74	306.78	351.72
Touch pad	320.80	75.65	16.92	285.39	356.20
Physical keyboard	108.75	20.57	4.60	99.12	118.38
New design	89.75	14.78	3.30	82.83	96.67

RAW-TLX Scores

The results show that Device 4 in Session 1 had the lowest rating score. The results from the one-way ANOVA (RAW-TLX score by Device) and the post hoc tests show that there were significant differences between the new design (Device 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p < 0.001$). There was no significant difference between the new design and the physical keyboard (Device 3; $p = 0.991$).

Table 2. RAW-TLX Scores of Four Devices in Session 1

Task	**Mean**	**Std. deviation**	**Std. error**	**95% confidence interval for mean**	
				Lower bound	**Upper bound**
Remote control	54.65	16.59	3.71	46.89	62.41
Touch pad	70.35	25.45	5.69	58.44	82.26
Physical keyboard	28.75	11.63	2.60	23.31	34.20
New design	27.05	17.45	3.90	18.88	35.22

System Usability Scale

The results from the one-way ANOVA (SUS score by Device) and the post hoc tests show that there were significant differences between the new design (Device 4) and the touch pad (Device 2; $p = 0.01$). There was no significant difference between the new design and the traditional remote control (Device 1; $p = 0.16$) or the physical keyboard (Device 3; $p = 0.21$).

Table 3. System Usability Scale Result of Four Devices in Session 1

Task	**Mean SUS score**	**Std. deviation**	**Std. error**	**95% confidence interval for mean**	
				Lower bound	**Upper bound**
Remote control	44.13	6.85	1.53	40.92	47.33
Touch pad	42.00	5.99	1.34	39.19	44.81
Physical keyboard	48.88	4.69	1.05	46.68	51.07
New design	46.88	5.31	1.19	44.39	49.36

Overall Self-Reported Form Result

The highest score reflected the best user satisfaction. The results from the one-way ANOVA (Overall score by Device) and the post hoc tests show that there were significant differences between the new design (Device 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p < 0.001$). There was no significant difference between the new design and the physical keyboard (Device 3; $p = 0.984$).

Table 4. Overall Self-reported Form Result of Four Devices in Session 1

Task	**Mean**	**Std. deviation**	**Std. error**	**95% confidence interval for mean**	
				Lower bound	**Upper bound**
Remote control	4.15	2.25	0.50	3.10	5.21
Touch pad	3.75	2.61	0.58	2.53	4.97
Physical keyboard	7.45	1.57	0.35	6.71	8.19
New design	7.20	2.17	0.48	6.19	8.21

Session 2: Text Editing Task Data

As in Session 1, the data from Session 2 included task times and the three questionnaires.

Completion Time

The results from the one-way ANOVA (Completion time by Device) and the post hoc tests show that there were significant differences between the new design (Device 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p < 0.001$). There were also significant differences between the traditional remote control and the touch pad ($p < 0.001$). However, there was no significant difference between the new design and the physical keyboard (Device 3; $p = 0.986$).

Table 5. Completion Time of Four Devices in Session 2

Task	Mean	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Remote control	291.55	42.36	9.47	271.72	311.38
Touch pad	89.00	19.51	4.36	79.87	98.13
Physical keyboard	45.90	9.41	2.10	41.50	50.30
New design	43.25	13.37	2.99	36.99	49.51

RAW-TLX Scores

The lowest rating reflected the best user satisfaction. The results from the one-way ANOVA (RAW-TLX score by Device) and post hoc tests show that there were significant differences between the new design (Device 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p = 0.002$). There were also significant differences between the traditional remote control and the touch pad ($p = 0.001$). However, there was no significant difference between the new design and the physical keyboard (Device 3; $p = 1.000$).

Table 6. RAW-TLX Scores of Four Devices in Session 2

Task	Mean	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Remote control	69.80	21.33	4.77	59.82	79.78
Touch pad	46.30	22.36	5.00	35.83	56.77
Physical keyboard	24.60	15.89	3.55	17.16	32.04
New design	24.00	16.34	3.65	16.35	31.65

System Usability Scale

The highest score reflected the best user satisfaction. The results from the one-way ANOVA (SUS score by Device) and post hoc tests show that there were significant differences between the new design (Device 4) and the touch pad (Device 2; $p = 0.007$). There was no significant difference between the new design and the traditional remote control (Device 1; $p < 0.06$) and the physical keyboard (Device 3; $p < 0.73$).

Table 7. System Usability Scale Result of Four Devices in Session 2

Task	Mean SUS score	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Remote control	42.63	7.37	1.65	39.18	46.07
Touch pad	41.75	5.63	1.26	39.12	44.38
Physical keyboard	47.13	6.55	1.47	44.06	50.19
New design	46.50	4.89	1.09	44.21	48.79

Overall Review

The results from the one-way ANOVA (Overall score by Device) and post hoc tests show that there were significant differences between the new design (Task 4) and the traditional remote control (Device 1; $p < 0.001$) and the touch pad (Device 2; $p < 0.001$). There were also significant differences between the traditional remote control and the touch pad ($p = 0.001$). However, there was no significant difference between the new design and the physical keyboard (Device 3; $p = 0.956$).

Table 8. Overall Self-Reported Form Result of Four Devices in Session 2

Task	Mean	Std. deviation	Std. error	95% confidence interval for mean	
				Lower bound	Upper bound
Remote control	2.65	1.50	0.33	1.95	3.35
Touch pad	4.90	2.10	0.47	3.92	5.88
Physical keyboard	7.75	1.68	0.38	6.96	8.54
New design	7.45	2.04	0.46	5.07	6.30

Discussion

The hypothesis of this study was that the new design would be more efficient and have higher user satisfaction than the three current methods when typing and editing text using a smart TV. The results show that the new design was significantly faster and had higher satisfaction than the remote control and the touch pad. However, there were no significant differences between the new design and the physical keyboard.

The four main findings of the study are as follows:

Finding 1: The new design and the physical keyboard allowed for faster text entry than the remote control and the touch pad.

The results show that using the remote control and the touch pad to type text on smart TVs was more time consuming compared to the physical keyboard and the new design. This result might have been caused by the different typing interactions of the four methods. When using the remote control and the touch pad during testing, most participants used one hand to hold the devices and used one finger (thumb) to press the buttons on the remote control or to touch the touch pad. While using the physical keyboard and the new method, most participants used two hands to hold the device and used multiple fingers to press buttons on the physical keyboard or on the virtual keyboard of the new app. This might mean multi-finger typing interaction was faster than single-finger typing interaction.

Finding 2: The physical keyboard and the new design had higher user satisfaction as text entry methods for smart TVs than the remote control and the touch pad.

The results from RAW-TLX, SUS, and the Overall Review show that the new method and the physical keyboard had significantly higher user satisfaction for typing text on smart TVs than the remote control and the touch pad.

The data showed that the touch pad had lower satisfaction for the typing experience than the remote control even though the touch pad was faster for typing text than the remote control. This might mean participants preferred to use physical interfaces (physical buttons) to type text on smart TVs compared to virtual interfaces (virtual buttons).

Finding 3: The new design and the physical keyboard allowed for faster text editing than the remote control and the touch pad.

Based on the results, the new design took the least time to edit text on smart TVs, and it was significantly faster than the remote control and the touch pad.

When participants used the remote control to edit text during the testing, the biggest challenge for them was moving the cursor in the sentence. Participants needed to delete most text when editing the sentence. The data also showed that the touch pad performed well when editing text. The reason might be that participants could easily move the cursor on the screen by using touch gestures. The physical keyboard was faster for editing text. When participants used the physical keyboard to edit text, they could press and hold the arrow buttons on the keyboard to move the cursor quickly.

Finding 4: The new design and the physical keyboard had the highest user satisfaction as text editing methods for smart TVs than the remote control and the touch pad.

The results from the RAW-TLX, SUS, and the Overall Review forms all showed that the new design and the physical keyboard had no significant difference for text editing, but these two methods had a significant higher satisfaction than the remote control and the touch pad.

Conclusion

The results indicate that for text entry, combining a virtual keyboard with touch pad type functionality can lead to faster text entry and text editing. In our study, this approach led to higher levels of user satisfaction.

As the core of input experience, typing and editing text has a significant effect on users' experience with smart TVs. Improving these tasks for current and future smart TVs not only enhance users' experience, but may help enable further innovation in smart TV features and interfaces.

Tips for Usability Practitioners

The following tips are to help practitioners who plan to evaluate text entry and edit methods for smart TVs:

- Providing touch pad and keyboard entry features in newly designed smart TV interfaces may provide a more effective and satisfactory end user experience.
- When evaluating multiple methods, tasks should be randomized to mitigate learning effects.

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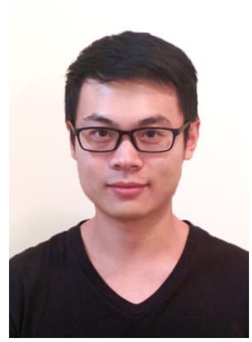

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