Evaluating the Usability of the Tails Installation Process

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COLLABORATION STATEMENT

This assignment was composed by Chris Austin, Tyler Brown, Michael Culleton, Shannon Devlin, Matthew Ferguson, Kaitlin Helfter, Kenneth Simpson, Wyatt Troutman, and Chris West. The roles in completing the assignment included collecting literature findings, brainstorming project ideas, attending group meetings, investigating technology, creating data scrapers, conducting usability tests, creating prototypes, writing, proofreading, and documenting citations in order to complete the assignment. All members provided purposeful discourse and helpful initiatives. We consulted related material that can be found at the References section.

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Executive Summary

Anonymous communication between hosts across a network has been a sought after feature since the inception of computer networking. Recently, with the increased public awareness of state censorship and corporation encroachment, users are more interested in maintaining privacy while on and offline [4]. In response, developers created technology allowing an individual to maintain full anonymity while conducting computer-based tasks. One example of this technology is the live operating system, Tails, as it allows users to complete all computer based tasks without leaving a trace on the device [8]. Although this technology gives individuals an unprecedented level of privacy and security, systematic usability evaluations have not been completed on Tails, and is therefore, the focus of this report. The following report details the current specifications of Tails, the methods employed to evaluate its usability, this evaluations' results and takeaways, and potential solutions to these findings in the form of a prototype.

Tails is a live operating system with anonymity as the paramount priority. It uses the Debian kernel and Gnome desktop environment in order to provide a smooth user experience. Packaged applications offer a complete library to maintain system and network anonymity [8]. One kernel function in use includes Tails defaulting all file system and swap to be maintained in volatile memory in order to keep any information from being stored on the device's disk. User web traffic defaults to using the Tor network for network routing which, when used properly, completely conceals the identity of the user when connecting to network locations.

The team plans to evaluate the usability of Tails by first evaluating current user needs by conducting a literature on known issues, examining posts of Reddit users currently troubleshooting Tails, and conducting an initial user evaluation by means of a cognitive walkthrough. From this investigation, the team will conduct action-based usability testing on specific processes in Tails so it can be evaluated systematically and objectively. Then the results will be analyzed in order to create a prototype addressing the found usability issues. This prototype will be evaluated by conducting the same action-based usability test as before so results can be compared to the current usability of Tails. Finally, the specific issues found in the usability test of the prototypes will be addressed by making necessary adjustments.

Investigating the usability of Tails is critical as users continue to want to protect their privacy while on and offline [4]. Having a private and secure experience with technology should be available to all those who seek it, not just to those who are technologically experienced [3]. Privacy and security focused technology has expanded to varying types of devices, like mobile applications [7], so it is important to understand current usability issues before Tails completes such an expansion. The team hopes a systematic and objective evaluation on the usability of Tails can deliver specific, insightful, and sustainable design recommendations that improve usability. In addition, the team contributes to the usable privacy and security field as it continues to become a widespread topic for a variety of users, software, and devices.

Introduction

Tails stands for The Amnesic Incognito Live Systems and its vision is "privacy for anyone anywhere" [8]. A live system is defined as an operating system (OS) that does not depend on the type of device [8]. It is part of the free software community [3] and its purpose is to give user anonymity when using a computer, online or offline. Tails is a one of a kind as it comes with an interesting background, innovative design, flexibility, and an unprecedented level of privacy and security. It is critical to understand these characteristics in order to understand the current version of Tails.

Background of Tails

Tails was started in 2011 by a group that wishes to remain anonymous (naturally) [3]. The group was inspired by the level of anonymity the Tor browser, i.e. a browser bouncing communications around servers so traceability to a specific user is near impossible [7], gives its users and felt an all-encompassing technology including all the current privacy and security focused tools would be the next step in this field [3]. Specifically, they wanted this technology to have items like Tor and encryption capabilities already installed so there with little to no work by the end user. The code name for this project was Amnesia and it was based on an existing live OS designed to keep a user anonymous at all times called Incognito [3]. These projects eventually came together to become Tails. The project was so successful at keeping the user anonymous for all computer-based tasks, Edward Snowden took advantage of it to leak sensitive information to the public [3].

How Does It Work?

Tails is a Debian-based Linux distribution developed to ensure user privacy, anonymity, and security before, during, and after each session of use. Tails is designed to only use the OS installed on the external drive of choice, (e.g. USB drive or CD), meaning it avoids using any of the computer's disks upon start up and use [8]. This means it does not use any of the computer's hard drives or swap space. The only storage space it does use is in RAM, so the live OS can run smoothly [8]. However, the user's identity is still concealed since after every session, both the live OS and the RAM are cleared upon shutdown. This is why Tails is described as "amnesic" as the operating system and all components "forget" the user after each use.

Tails also keeps the user anonymous by having all internet browsing traffic routed through the Tor browser. So even if an application is coded to connect to the internet directly, Tails will block the connection and reroute through Tor [8]. Tor is able to avoid the ramifications of a man-in-the-middle attack as the path the connections takes through the servers is completely random and the information is encrypted [7]. This gives the user the benefit of anonymity and potential access to content not normally available to them due to censorship. Additionally, Tails has encryption tools such as open-PGP for secure online messaging. It also can encrypt files, even when offline, by the use of LUKS [8].

Application

One of the most used applications of Tails is the ability to avoid censorship [3, 8]. Some countries and organizations track the web activities of their citizens to control the activities conducted and information online. Since Tails routes

their traffic through Tor, the user's identity is concealed and near untraceable. Similarly, users can browse the internet without worrying if their personal data is being collected by corporations and marketing researchers alike. Also, users can send encrypted emails using the pre-installed open-PGP. Additionally, Tails can also be used on public computers to prevent you from leaking private personal data in a public place and encrypt personal data files for safe storage.

Installation Process

All information in this section can be referenced at [8]. To begin using Tails, it must first be installed on an external drive such as a USB drive or CD. The installation requires a computer, internet connection and two external drives exceeding 8GB. For the sake of explaining the installation procedure, it is assumed the appropriate USB drives are being used. The whole installation process can be divided into five steps. The first step is installing intermediary Tails, and starts with downloading the ISO image file off of the Tails website. Once the image file is downloaded, plug in one of the USB drives and run the Tails program to install the image file to the USB drive. Once that finishes installing, intermediary Tails is on your USB drive. The USB drive should remained plugged in to the computer and the computer should be restarted to boot in to Tails, which may or may not happen by default. The Tails website states there may be additional actions to take depending on the computer if the Bootloader Menu for Tails did not appear. However, assuming it does appear, select the USB from the Boot Loader menu and enter intermediary Tails. Insert the second USB drive and open the Tails Installer. In the "Target USB drive" drop down menu, select the second USB that doesn't have intermediary Tails installed on it. A second USB drive and install is used to avoid having a user's metadata on Tails, which came with the original ISO install. Keep the "Clone the current Tails" radio button selected and hit install. After the installation completes, shutdown the computer and unplug the original USB drive (the one with intermediary Tails installed). Finally, turn on the computer and boot into the USB with final Tails installed.

Previously Identified Issues

While Tails is a one of a kind live OS, it is not without issues. First, Tails does not separate the user's various contextual identities [9]. For example, if a user accesses a social media application and then accesses a private forum, it is possible to link the two events [3]. Second, Tails is not a completed product [9], rather a continual work in progress and subject to minor or major malfunctions and needs consistent updating. This could easily reduce the usability of the software if users are continuously having to relearn the system they are using. Third, the Tails installation process varies greatly depending on the used hardware [9]. Due to most computers needing to access the BIOS settings when installing Tails [9], users must have some advanced computer knowledge in order to install it. Lastly, Tails does not guarantee full security or anonymity [9]. For example, a compromised host, physical media, or BIOS can lead to a compromised system and the user may remain unaware. These are important issues that users should be aware of before using the Tails operating system.

Evaluation of User Needs

Overview

This section details how the team investigated the needs of Tails users. The team made three consecutive investigations: the first exploring the subreddit of Tails, the second consisting of having three team members conduct an initial user evaluation, and the final being an action-based usability assessment. The method and results of each investigation are presented in tandem to help explain the team's thought process throughout the evaluation of user needs.

Methodology of Reddit Post Evaluation

Reddit is one of the many forms of social media that allows users to conceal their identity as it allows user to engage with its content with just a username [1]. Reddit contains discussion boards, called subreddits, where users can freely share information on a whole variety of topics [1]. Since no one on the team had a direct connection to someone who uses Tails and finding a Tails user was predicted to be difficult due to their innate prioritization of anonymity, the team decided to investigate the subreddit on Tails to gain some initial insight on current usability issues. The team gathered posts by running a program called a scraper on a web server. The specific framework, called Scrapy, ran on an Amazon Web Services Elastic Cloud Compute instance. The posts were stored on a noSQL database called MongoDB in a Javascript Object Notation format. The scraper collected posts from the last 3 months and analyzed the data.

Results of Reddit Post Evaluation

A total of 52 posts were collected from the Tails subreddit. Due to the manageable sample size, each post was read through and categorized as one of the following issues: installation, software, hardware, or usability. Posts were categorized as an installation, software, or hardware issue if it related to the respective topic specifically. For example, several posts said the mouse stopped working properly once in Tails and the team identified this as a software issue. Finally, a post was categorized as a usability issue if it was related to completing tasks, understanding error messages, or inquiring about components of Tails. For example, one post was an inquiry on how to connect Tails to their WiFi network. With this categorization process, 13.7% of the posts were categorized as installation issues, 32.7% were categorized as software issues, 17.3% were categorized as hardware issues, and 36.5% were categorized as usability issues.

The team discussed the findings and their implications. It was clear a usability investigation was warranted as it accounted for the largest percentage of posts, which is expected as this is the nature of the subreddit. However, after reading through the posts the team discussed, if Tails's vision is "privacy for anyone anywhere", what was being done to assure this was the case? To answer this, the team looked in to the nature of installation issues thinking if users are not successful installing Tails, then it automatically fails its vision. Although they were the smallest proportion of posts, the team discussed this

may be the case as those installing Tails for the first time may not think to reach out to a subreddit for two reasons: (1) users may be unaware of the subreddit, as research has estimated only 4% of adults in the United States are Reddit users [1] and (2) the Tails website gives installation instructions and is so in depth in general, users may have felt if they could not install Tails with this resource, no other resource could help. If this were the case, then 13.7% is a considerable percentage. To further understand this potential installation process usability, it was decided three team members, who had never installed Tails before, would complete an initial user evaluation by conducting a cognitive walkthrough of the full installation process of Tails. A cognitive walkthrough aims to uncover mismatches between the functionalities of a system and the user's thought process [5].

Methodology of Initial User Evaluation

The three initial evaluators followed the directions provided by tails.boum.org. Two of the three evaluators used Lenovo laptops running Windows, while the third used a Macbook Pro running Linux. The user conducted a cognitive walkthrough in accordance with the four-step process suggested by [5]:

1. Select a task to be performed. In this case, it was the installation process of Tails.
2. Explore the system for an action allowing you to perform this task.
3. Select the action that best fits the desired goal.
4. Interpret the system's response and assess if it has taken you any closer to your goal.

The evaluators compiled notes during and after the download and install process and the group reviewed the findings.

Results of Initial User Evaluation

Initial evaluators completed the entire installation process of Tails and rated the difficulty of each step on a scale of 1-5 with 5 being the most difficult. The steps were in accordance with the directions provided by Tails. Table 1 shows the ratings on each step as well as their estimated time to complete all tasks. All average ratings greater than 3 are highlighted in red text.

Table 1: Initial Evaluators' Difficulty Ratings

Step	Evaluator 1	Evaluator 2	Evaluator 3	Average
Step 1: Download the Tails ISO	3	2	2	2.3
Step 2: Install intermediary Tails	3	2	3	2.7
Step 3: Boot into the intermediary Tails	4.5	4	4.5	4.3
Step 4: Install Tails on 2nd USB	2	2	2.5	2.2
Step 5: Boot into Tails	1	1	1	1

Estimated total time	30 min	60 min	90 min	60 min

Immediately, the variability that exists in installation time is evident. Additionally, Table 1 highlights how Step 3 was rated the most difficult across all evaluators. To further understand why, their observation for Step 3 was examined and presented in Table 2.

Table 2: Initial Evaluators' comments on Step 3

Evaluator 1	Evaluator 2	Evaluator 3
The **directions say** upon reboot, Tails **should go straight to Tails**. Depending on the device, you **will probably have to go into your BIOS** to actually tell the computer to boot into Tails. **I use rEFind** on my Mac so it gives me the option to select it when I restart my Mac. **My browser wasn't verified for directly downloading Tails.** This could cause some confusion with normal users	I see this giving some people a little trouble because it involves going to the boot menu at startup. The instructions do walk the user through how to get to the boot menu and install from there, but as the boot key depends on the computer, **the user may have to look that up themselves**	**A lot of instruction is missing here.** I ended up **googling** specific boot options because my laptop did not boot to the USB. Once figuring out how to boot to a USB, I received a **"no configuration file found"**… **After more searching**, I found that I could not have my BIOS settings to boot in UEFI mode [the computer's default] **For someone who is inexperienced with installing operating systems to a flash drive could have assumed Tails did not install properly.**

From these comments, it is clear completing Step 3 of installation process was not straightforward. The evaluators relied on external resources extensively as well as previous knowledge and experience. They had to decode through cumbersome and unclear instructions, error messages, and system components. These initial findings indicate usability issues for Step 3 and a need for a further investigation.

In order to improve the usability of this step, the team felt an action-based usability test would lead to insightful findings and improved design. The team agreed Step 3 was in need of a redesign due to it being counterintuitive and it relying on unfamiliar items (e.g. editing the BIOS of the computer). However, the team also noticed something interesting in the observation notes for Step 4. It received low difficulty ratings, but all evaluators also indicated they relied on documentation to complete this step, which turned out to be simply opening an installer window and installing Tails on a second USB – a process believed to be relatively straightforward by team members. The team wondered, what would happen if the evaluators did not have access to that documentation? Was the user interface of Tails informative and intuitive enough for users? To answer these questions, the team decided to add Step 4 to the usability test.

Methodology of Action-based Usability Assessment

Participants

The team decided to have participants be undergraduate computer science majors from a large university in the southeast in order to best control for

computer and technical experience. The team chose these participants thinking if the non-average user was having difficulties installing Tails, then it is very possible general computer users would have the same, if not more, difficulties. Two pilot tests were conducted so experimenters could practice and assess the usability test. Then five official usability tests were conducted with the computer science majors as participants.

Specific Tasks Evaluated

As discussed above, the task to be evaluated were Step 3 and Step 4 as the former was rated the most difficult step and relied on a lot of external resources and the latter would better evaluate Tails's user interface (UI). Additionally Step 3 and 4 encompassed Steps 2 and 5, (as the introduction explains) so it was a very streamlined way to have a holistic evaluation of the installation process. The team decided to allow participants to use an external resource of their choosing when completing Step 3 for two reasons: (1) the Tails website instructs you to have access to instructions beforehand (2) all the evaluators relied heavily on their external resource to complete the task. To assure the team was evaluating Step 3's true usability, it was important to simulate a realistic environment. As for Step 4, the team wanted to test the UI of Tails strictly, so no external resource was allowed.

Experimental Equipment

In order to control for differences in machinery, all participants used a Dell M3800 laptop with a Windows 10 OS and default BIOS settings (i.e. Secure Boot option was on). Two USB drives were needed to complete the task: one with intermediary Tails on it and a blank one to accurately simulate Step 4. Participants were automatically provided with the USB drive that had intermediary Tails on it. They were allowed to use any internet-enabled external resources. In the second part, they were not given the second USB until they explicitly asked for it in order to better understand the participants' understanding of the system.

Measures of Interest

The measures of interest fell in to three general categories: quantitative, qualitative, and debriefing data. Quantitative data included completion rate and time through task, number of errors, and number of think aloud statements. Time through task indicates how long the participant took to reach each step within the task. This was used instead of time on task as the Initial User Evaluation showed completing tasks were mostly selecting options and seeing if they would work and some steps within the task could be done correctly out of order, so finding how long it took to reach each step and complete it correctly was more of interest. The completion rate was the percent of participants who successfully completed both Step 3 and Step 4. The number of errors was defined as the total number of error messages and general errors made across all participants. Finally the total number of think aloud statements and returns to an external resource was recorded for all participants.

The team collected the qualitative data of think aloud statements and time-stamped observations to further understand the complete usability of Step 3 and Step 4. Finally, the team collected debriefing data to learn and understand the participants better. This included recording demographic data

(i.e. previous experience with live OS) having them rate scale questions about the task, and having them reflect on the task with free response questions.

Procedure

All participants were recruited personally by asking if they wanted to strictly volunteer to be a participant in the usability assessment. Each experimenter (2-3 total) greeted the participant prior to beginning the test. One observer explained what the task was and that an external resource could be used for the first part but not for the second part of the task. The experimenter asked the participant if all the types of data previously discussed could be collected and waited for the participant to consent. After consent was gained, the first part of the task started and ended when the participant indicated they were in Tails. The time was reset and the second part began as soon as both participants and experimenters indicated they were ready and ended when the participant correctly identified the button that would have to be clicked to start the final download. Participants did not explicitly click this button due to time and hardware constraints (it would take a long time to download and we did not want to have to reformat the black USB). After both parts were completed, they were then asked to fill out a debriefing survey and then were thanked and dismissed.

Results of Action-based Usability Assessment

Each measure of interest will be discussed and then summarized. For brevity, the measures of number of errors and number of returns to an external resources will be part of the time through task presentation of results and the number of think aloud statements and observations will be presented with the results of their themes.

Task Completion Rate

One experimenter collected success rate data as the participant completed each task on his/her own. The task success rate is the number of successes divided by the number of participants. Completion rate for Step 3 and Step 4 was both 80% (4 out of 5 participants) and details are further discussed

For Step 3, all participants successfully inserted the USB with the intermediary version of Tails on it and entered the BIOS settings. From there, four out the five participants successfully completed all the subsequent steps. All participants successfully completing Step 3 relied on an external resource at one point, but usage was also varied, ranging from the fastest participant searching for the meaning of a single error message to the slowest participant utilizing three different websites.

The participant who did not successfully complete Step 3 utilized an external resource 6 separate times, recreated an error message 5 times, and never successfully changed any of the BIOS settings, just simply searched around the BIOS. The participant indicated he/she wanted to end this phase of the experimental session as his/her next step would be to post on an online forum and wait for a response, but did not actually want to do this in the experimental session due to time.

For Step 4, one participant checked if the current version of Tails to assure it was up to date as this is explicitly stated in the Tails documentation within the Tails system. Four of the five participants accessed the Tails Installer via the Application drop down menu, while one participant simply searched for "tails install" and clicked on the first search results to reach the Tails Installer. From there, all participants inserted the 2nd USB, however, completion rate dropped to 80% for all subsequent steps as one participant believed it was impossible to complete the process without an internet connection and decided to end the experimental session once reaching this conclusion. Reasons for this conclusion will be discussed in the observations section.

Time through Task

One experimenter collected time for both Step 3 and 4 described above. To reiterate, the time through task data is a timestamp of when the participant completed each step of Step 3 and 4. Time through task data for Step 3 and Step 4 are presented in Table 3 and Table 4, respectively.

Table 3: Time through task for Step 3 [s] (Participant abbreviated to Part.)

Part.	Insert USB	Enter BIOS	Disable Secure Boot	Change Boot List Option from UEFI to Legacy	Change Boot Priority so USB is highest	Save & Restart Computer	Boot into Tails
1	1	252	282	300	312	335	362
2	2	902	1082	1150	1217	1255	1324
3	1	960	1061	1156	1157	1161	1185
4	1	-	-	-	-	-	-
5	1	105	1836	1901	1919	1922	1946
Avg. Time	**1.2**	**554.8**	**1065.3**	**1126.8**	**1151.3**	**1169.5**	**1204.3**

For Step 3, all participants immediately inserted the USB with the intermediary version of Tails. From there, four out of the five participants completed all the subsequent steps, with varying total time durations ranging from 362-1946 s. All the participants who successfully entered Tails had large gaps in time before entering the BIOS setting, with one taking as long as 960 s. After further investigation, the slowest participant accessed an external resource five separate times and spent approximately 600 s exploring the options in Windows and not the computer specifically. The fastest participant accessed an external resource 1 time and did not spend any time in Windows. The other two middle performing participants accessed an external resource two and three times and spent an estimated time of one and three minutes exploring the options in Windows, and recreated error messages three and six times, respectively.

The participant who did not complete all of the steps in Step 3 participated in troubleshooting and researching for 2,115 s, but struggled to complete any additional steps in the task. The participant said he/she would post on an online forum and wait for a response if completing this task outside the experimental session, and therefore wanted to end this part of the experimental session at 2,115 s.

Table 4: Time through task for Step 4 (Participant abbreviated to Part.)

Part.	Go to Application	Go to Tails	Go to About Tails & check version	Go to Tails	Go to Tails Installer	Insert 2nd USB	Select Clone current Tails	Choose 2nd USB in Target USB drive drop-down list	Click Install button
1	-	-	-	-	59	84	101	206	236
2	177	-	-	180	184	191	237	250	267
3	319	321	323	330	331	611	630	642	665
4	11	-	-	17	25	-	-	-	-
5	158	-	-	165	169	288	392	427	509
Avg. Time	**166.3**	**170.8**	**323**	**330**	**153.6**	**293.5**	**340**	**381.3**	**419.3**

For Step 4, total time duration was greatly less and not nearly as varied as Step 3 as it ranged from 236-665 s. Although four of the five participants accessed the Tails Installer via the Application drop down menu, the fastest participant simply searched for "tails install" and clicked on the first search results to reach the Tails Installer. The slowest participant spent the most time figuring out the hardware necessary to complete Step 4 and referred to documentation within Tails extensively. This participant was also the most confused by some technical jargon used by Tails and this implication will be discussed further later. Interestingly, the participant who completed step 1, 4, and 5 the fastest failed to complete the entirety of Step 4 as this one participant stated in was impossible to complete the process without an internet connection and decided to end the experimental session once reaching this conclusion.

Qualitative Data

While completing the step, think aloud statements and general observations about the participant and process were collected. A general overview of the data collected is displayed in Table 5.

Table 5: Breakdown of number of errors, think aloud statements, and observations

Step	Number of errors incurred	Number of Think aloud Statements generated	Amount of observations recorded (in number of bullets)
3	27	39	410
4	5	25	157

The qualitative data was compiled and organized to understand any emerging themes arising during the experiment. Four different group members, with two being involved in usability testing, read through all the qualitative data and highlighted recurring errors, thoughts, and observations and the following themes were found.

Errors

Errors were tabulated by tallying the amount of times the user made an incorrect action or encountered an error message from Tails or the computer. In Step 3, errors existed for one of three categories: where and what settings to change, error message meaning, and misunderstanding, or not correctly identifying instructions. In Step 4, errors included selecting the incorrect first step, misunderstanding technical jargon, and misidentifying necessary hardware and documentation.

Think aloud statements

Understanding when users were confused or unsure about their interactions with Tails was of interest. The think aloud statements that indicated uncertainty (i.e. containing phrases such as "I don't know", "not sure", "I have no idea", "I assume", "I am lost") were tabulated and found to be present 38 times across all five participants, accounting for 59.3% of all think aloud statements. These statements came when asking why a participant was completing a certain step, why the computer was responding to system changes in a particular manner, what a certain error message meant, or what a specific term in Tails meant. In contrast, statements indicating confidence and certainty in their actions ("I know it is because" or "So I can do this") were recorded a total of 8 times across all participants and related to knowing where certain information would be stored in documentation, knowing what booting into a live operating system entailed, or where certain computer options would be edited.

Observations

An observation was defined as recording a particular characteristic or action of a participant or the system. For Step 3, observation data captured the tendency of participants to not complete steps or read documentation in a serial manner, meaning a trial and error approach was employed by each participant. Additionally, four out of five participants expected intermediary Tails to have some sort of functionality on the Windows OS, whether it was as simple as having install instructions in the README file or being able to run a program of some sort. The observation data indicated that four out of five participants exhibited signs of frustration or confusion during some point of Step 3.

As for Step 4, the observation data found the completion path Tails outlines was not obvious as all participants had to rely on internal Tails documentation or trial and error to access the final steps of Step 4. Additionally noted was the lack of purpose for all desktop icons with respect to completing Step 4 and just served as distractors for three out of five participants. Finally, the observations captured participants did not immediately know what hardware was necessary and where to go for documentation. Only two participants asked for a second USB without troubleshooting or relying on documentation. Additionally, one participant stated there was no way to complete the task without internet connection as he saw a link labeled "Installation Instructions" and didn't explore any other options in Tails for help instructions, even though there were other helpful resources within Tails, just as the four successful participants found.

Debriefing Data

Four out of the five participants completed the debriefing survey. Two participants had previous experience accessing a live OS from a USB, all participants indicated they are exposed to new technology at least 2-4 times a month and troubleshoot technology with the internet most or every time. Finally there was a large range of experience with modifying the BIOS (from none at all to a lot).

Additionally, participants rated the ease and difficulty of completing each task by answering the following questions with a 10-point rating scale ranged from 1 (least) to 10 (most) and the results are shown below in Table 6. Questions asking about difficulty with an average score greater than 6 are highlighted. Similarly, questions about helpfulness and understanding level with an average score less than 4 are highlighted.

Table 6: Participant ratings and average rating for each scale question

Question	Participant 1	Participant 2	Participant 3	Participant 5	Average
Overall Difficulty	2	8	8	7	6.3
Overall Frustration	2	10	6	10	7
Difficulty of accessing the BIOS setting	2	3	5	2	3
Difficulty of editing the BIOS setting	1	4	3	2	2.5
Helpfulness of tails.org	N/A	N/A	6	10	8
Helpfulness of error messages	4	2	6	4	4
Understanding of need to edit BIOS	10	3	2	1	3.8

The team further investigated the highlighter rating by looking at participants' answers to the free response questions that were most applicable. Only one participant indicated they were confident completing the task. Two explicitly said they were confused why Tails had no functionality in the Windows OS and did not really know why disabling secure boot within the BIOS allowed Tails to finally be accessible. To reiterate, all participants indicated they used an external resource, and the resources included, the Tails website, a subreddit, and a StackOverflow thread. With respect to Step 4, participants indicated the most challenging process included finding the installer, ensuring the install settings were correct, and understanding the reason for the specific install settings.

Summary of Data

After analyzing all the data, there are some findings to discuss in general. Overall, completing Step 3 was involved for all users as it proved to be very time consuming and difficult to complete, especially considering it was only one of five steps of the entire installation process and did not even include the time it takes to download Tails. Furthermore, accessing Tails was not a guarantee as completion rate was 80%. Moreover, prior experience with live

operating systems helped with the understanding of how to access Tails, but difficulties were still incurred for those two users. Additionally, Step 4 proved to not have a clear path to success and confusing technical jargon in its design as internal documentation was relied on by four out of five users which is not a good sign of UI intuitiveness. After all of the data analysis, there are a variety of usability issues needing further attention, from total system implementation design to word choice on the user interface. In order to further pinpoint commonalities and emerging themes of usability issues existing during Step 3 and Step 4 of the installation process, the team came together to discuss the two overarching themes causing usability issues.

Conflicted Mental Models.
A mental model is the structure the user personally creates to understand how the system components are interacting and functioning [6]. Participants struggled to form a complete and correct mental model of the Tails install process. This is supported by the large gaps in time seen Time through task in Step 3 (e.g. disabling secure boot in the BIOS) and Step 4 (e.g. understanding the purpose of the 2nd USB drive).

In Step 3, Windows was accessed and interacted with by a majority of participants. This is most likely due to the computer defaulting to Windows on boot up and Tails being on a USB, a device typically having functionality in the Windows OS. Four out of five users indicated they did not understand **why** editing BIOS was necessary - they just realized it needed to be done. These two items indicate here that users' mental models of Tails is very incorrect. Tails has no functionality in the Windows OS since it is its own OS and participants were not only told this, but they also had an external resource to specifically find this out. However, this is not a user error as Tails allowed the computer to enter Windows and have the USB drive be read in Windows, so participants became anchored in their original mental model. When participants did explore Tails's functionality in the Windows OS, no feedback was given by Tails itself. Participants had the entire internet to use for this task, so it wasn't for a lack of information, but rather system design. It could be argued having access to the internet for this task is not even a guarantee as those wishing to access Tails are seeking privacy and anonymity on the web, so they may not search about it in fear of losing privacy and anonymity, making internal feedback crucial for success in to Tails, especially when users are troubleshooting.

Adding to the evidence of conflicted models, in Step 4, three out of five participants did not understand why a 2nd USB was needed and two of out five participants were confused by the use of the word "clone" when selecting the install options for the 2nd USB. This relates to not understanding the purpose and structure of intermediary Tails. In reality, intermediary Tails is no different than Tails - the reason it is ever presented as being different (as done on the Tails website) is because a 2nd download is needed to assure no personal metadata is existing on the user's final version of Tails as this could compromise the user's anonymity. However, the instructions nor system never fully explain this caveat, leading users to think the first Tails system they interact with is incomplete, which is false.

Unclear Path of Success
None of the participants completed any part of the task in a serial manner, even when relying on the instructions. This indicates the UI components and the internal documentation are not clear, linear, and informative. The team

found the website operates more like a repository/database of information, not a user guide. Although the website is not lacking any information, rather struggling from the opposite, the team feels truly usable technology would not have its users rely so heavily on documentation, rather the design of the technology would lead users to interact with it in most optimal manner by design.

Recommendations for Improvement

The team felt an installation process addressing the two overarching issues would lead to a better user experience. Specifically, the team's goals included having users understand what and why they are completing each step of the installation process, no reliance on an external resource to complete the task, and a streamlined task completion. The specifics of how this would be achieved are detailed in the next section.

Prototype Generation and Evaluation

Visuals and Description of Prototype System

All members of the team discussed potential prototype solutions addressing these implemented in a prototype. The team decided there were several issues to address, ranging from the inherent design of the installation process to specific word choice. The team discussed and decided eliminating the need to enter the BIOS manually, addressing the cumbersomeness of intermediary Tails, and making the installation as streamline as possible by design would address the many other specific concerns observed. Below details how the team generated ideas and created a prototype.

Discussing Types of Potential Prototypes

When discussing the details of the potential prototype, the team was faced with the decision of making only incremental, feasible changes to the existing system or making a new system entirely that may rely on technology currently outside of feasibility. The first option would have been easier to compare and contrast to the existing system but actually addresses issues with PC error message wording, Tails website design, and Windows OS features. Focusing on a total redesign of the Tails installation itself would be more relevant to the goal of the project: to deliver specific and objective design specifications to increase usability of Tails. Even though a total redesign may mean relying on technology that does not yet exist, it was ultimately decided to overhaul the system entirely to address the major usability issues directly. Once this was decided, the team set out a list of final goals: making installation far more streamlined, intuitive, and transparent. Specifically, the team wanted users to complete Step 3 and Step 4 in half the time found in the original usability assessment, to be able to forgo the use of external resource and a list of instructions entirely, and remove the need for intermediary Tails.

Prototype Presentation

The prototype created to address the above goals and specifications has the user ideally only needing to complete four actions to access Tails: start the computer, insert a USB with Tails already installed on it, run a configuration program (one that correctly configures the BIOS and removes a user's metadata automatically), and restart the computer. A prototype with these steps is streamlined, intuitive, and transparent as it does not require prior knowledge other than familiarity with the basic functions of a USB drive and interacting with an executable program. This prototype combined Step 3, 4, and 5 from the Initial User Evaluation and avoided the BIOS and intermediary Tails completely. Due to limited resources and current feasibility, this prototype was created in Microsoft PowerPoint so users could actually interact with a computer, and required the help of an experimenter to make a "Wizard of Oz" [2] type action and can be seen in Figure 1.

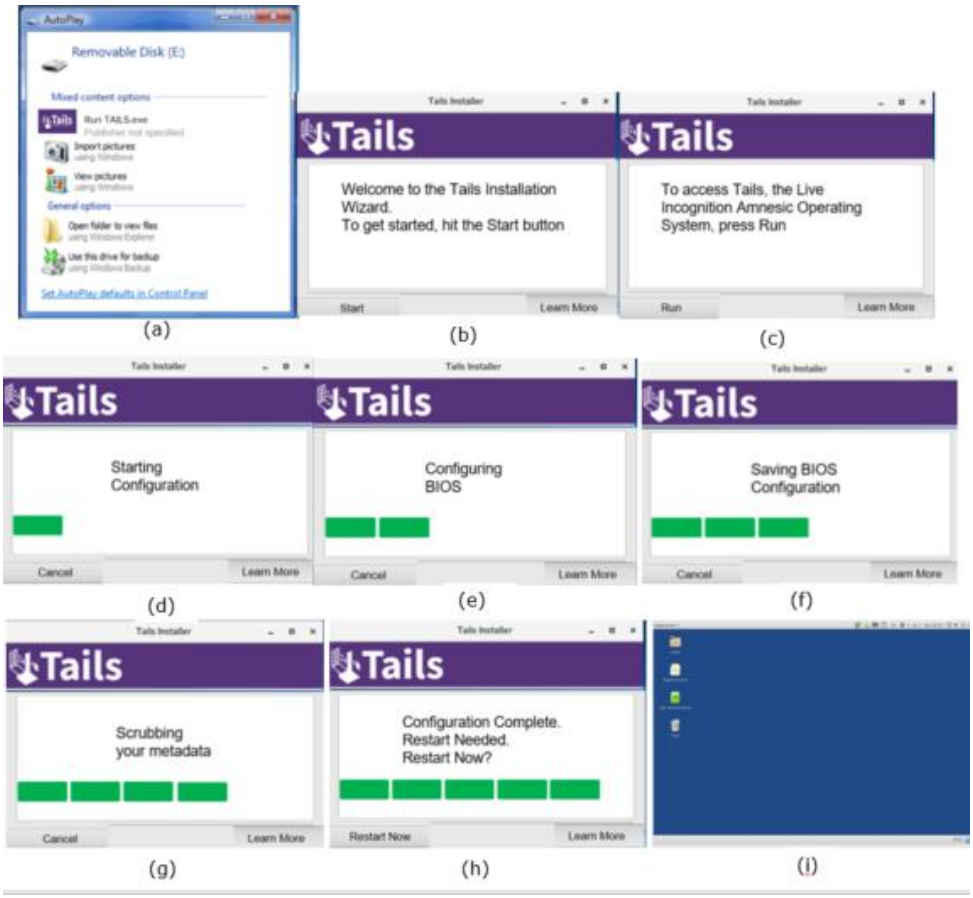

Figure 1: Slides of Prototype in sequential order

Specifically, a set of interactive (i.e. clickable) slides simulated the four steps above (labeled (a)-(i)). The only action not controlled by PowerPoint was when the user inserted the USB and the experimenter advanced to the next slide where the AutoPlay window automatically popped up, (i.e. a "Wizard of Oz" action). In the AutoPlay options, a TailsPrep.exe was listed and able to be

clicked on. From there a user would simply need to run the executable to configure the BIOS to the appropriate settings, "scrub" the metadata off of current install of Tails restart their computer, and upon restarting the computer, Tails would be automatically accessed. Additionally, there was a slide linked to the "Learn More" button and it briefed the participant on what the executable was doing and where to go for more information. The reason why it is not pictured will be explained further in the Results of Prototype Evaluation section.

The team felt this prototype transformed a counterintuitive and cumbersome installation process into a relatively quick, intuitive process since it used the familiarity of Windows OS, USB drives, and executable programs. In reality, configuring the BIOS from an OS and "scrubbing" metadata off downloads is currently infeasible, but they better match the mental models found in user testing. It is important to note that the ability to configure BIOS settings from within an OS would require more research as to the repercussions of its use.

Methods used to Evaluate Prototype

The exact same usability tests done with the current Tails installation process previously was used to test the prototype, with additional instructions given about the nature of the prototype. This was done to (1) assure comparable results across usability tests and (2) gain the same level of insight the previous test gave to the team. However, when participants answered the debriefing survey, they left sections that did not apply to them (e.g. "How difficult was it to edit the BIOS?") unanswered as they did not actually complete this task.

Results of Prototype Evaluation

Each metric of interest will be discussed in the same format as before.

Completion Rate

Every user managed to successfully enter Tails (i.e. completion rate was 100%), which is an improvement from the 80% completion rate seen in the initial usability test.

Time through task

Table 7 shows the time through task data when using the prototype. In comparison with Table 3, which is the time through task using the current Tails, the average time for almost every step drastically decreased, with the actual final step of installing the final version of Tails taking on average 1623.6 s, which in the prototype dropped to 92.4 s, producing a dramatic decrease in average install time. The range of values for the prototype is also substantially lower than the ranges from the initial usability assessment.

Table 7: Time through task for prototype (Participant abbreviated to Part.)

Part.	Turn on Computer	Insert USB	Click on Tails Autorun	Click Start on Dialog Box	Click Run on Dialog Box	Click Restart on Dialog Box	Enter Tails
1	10	20	22	24	26	92	120
2	2	11	13	15	19	50	67
3	5	25	28	35	38	70	89
4	3	22	28	31	40	92	102
5	3	30	35	40	43	76	84
Avg. Time	**4.6**	**21.6**	**25.2**	**29**	**33.2**	**76**	**92.4**

Qualitative Data

Table 8 displays the breakdown of number of error messages, think aloud statements and observations.

Table 8: Breakdown of number of errors, think aloud statements, and observations

Number of errors incurred messages	Number of Think aloud Statements generated	Amount of observations recorded (in number of bullets)
0	10	169

Due to brevity, the session generated less qualitative data. However, it is worth noting that users conducted zero errors and of the 10 generated think aloud statements, only 2 (20%) were ones of uncertainty which is an improvement from the previous system (59.3%). However, there were 4 instances where participants were incorrect about what was exactly happening in the executable. One believed that Tails was installing for the first time and the other thought Tails was being installed on to the computer. Finally, observation themes included immediacy to clicking on the executable and start button and no indications of frustration, but three participants were slightly unsure if they were actually in Tails once reaching the Tails desktop.

Debriefing Data

As for demographics of the participants, there were no major differences in experience with troubleshooting technology and interacting with a live OS, which is expected since the participant demographic remained constant between both usability tests. Table 9 shows the relevant responses to the scale questions in the debriefing survey. The average score of the overall difficulty and overall frustration decreased by 2.1 and 5.4 points, respectively. The average score of the level of understanding of why the BIOS was edited increased by 2.6 points. Ranges in these ratings also decreased, which may imply the successfulness of completing the usability test relied less on differences between users and was based more upon the actual usability of the system.

Table 9: User submitted survey results for the prototype usability test

Participant	Overall Difficulty	Overall Frustration	Level of understanding why BIOS was being edited
1	2	1	7
2	1	1	7
3	3	2	9
4	4	3	8
5	1	1	1
Avg. Rating	**2.4**	**1.6**	**6.4**

Implications of Evaluation

The prototype was rather successful in improving on the original issues found from the initial usability tests. The time through task and frustration were greatly reduced. The average time taken to install Tails with the prototype was about 90 s, a period of time which is comparable to the time needed for current Installation Wizards. This time savings comes with no tradeoffs, as privacy, security, and anonymity are ensured for the user since counterintuitive, but critical processes are automated. Also, completion rate and overall understanding of the system increased without any of the team's previous specifications being missed (e.g. the need for external documentation). Therefore, the team is confident the proposed prototype is an improvement from the original installation process and aligns closer with Tails's vision of "privacy for anyone anywhere".

Despite this, the prototype can clearly use even more improvements. While the participants were able to complete the usability test more quickly and with more confidence, the think aloud and observation data indicated there was still some uncertainty about what was exactly happening with the executable and when they were actually in Tails. The team decided this indicates the transparency of the system could be increased. Transparency issues could be a problem when a user develops a mental model and a goal of this prototype was to have participants to construct better mental models by default. The team originally addressed this concern with a "Learn More" button, but interestingly, no users clicked this button. Upon further investigation, the participants generally indicated the installation seemed to be working so there would be no need to deviate from the dialog boxes. This indicated to the team relevant information needed to be presented more saliently and immediately to truly improve user mental models by design. Finally, the experimenters observed hesitation in three participants when they reached the Tails desktop, so the team decided to address this issue similarly by providing information immediately upon entering Tails.

Mock-ups of recommended changes based on results of evaluation

Since usability testing indicated the prototype needed to better address users' mental model of the Tails configuration process with more informative, clearer, and immediate information, the following change were made to the prototype and are listed in Table 10.

Table 10: List of changes to prototype and justification

Change	Justification
1. Changed dialog boxes' title from "Tails Installer" to "**Tails Configuration**" 2. Changed executable name in AutoPlay menu (slide (a) Figure 1) to "**TailsPrep.exe**" 3. Removed "Learn More" button 4. Slide (d) (Figure 1) now says "Configuring BIOS **so Tails is accessed upon startup**" 5. Slide (f) (Figure 1) now says "Scrubbing your metadata **to assure anonymity**" 6. Slide (i) (Figure 1) has the message "**Welcome to Tails! Your identity is now anonymized**." on the desktop and directed users to go to tails.org to learn more on identity anonymization	• Three out of five participants indicated Tails was performing some type of installation. Changes 1-2 were made to more clearly indicate the executable was configuring the computer so Tails could be accessed • Zero participants clicked on this button, so it was removed to decrease the chance a user would go astray • Three out of five participants' mental models were incorrect. Changes 4 and 5 add explanations for why specific actions were taken in order to better develop mental models • Two out of five participants from our prototype's usability assessment, as well as two out of five from our original usability assessment, exhibited uncertainty when asked when they were in Tails, Change 6 was made to make it clearer as well as to provide extra information on how to avoid compromising one's identity.

Conclusion

Final Thoughts

The findings show that the installation process of Tails fails to give the user a straightforward, transparent and streamlined experience. The team created a prototype addressing those findings, tested it, and further solved major issues of the installation process. A full usability evaluation, which included action-based usability testing, proved to be insightful, as it gave specific and objective specifications about how to design a user-centered installation process.

Limitations

The limitations encountered during this evaluation included a small sample size of a very specific group of users. Although specifically testing with American computer science students has its advantages, understanding how other user populations interact with Tails, like those varying in age and global region, may be of interest. Additionally, future data collection methods could use more precise technology like video recordings of the participant and his/her screen or eye tracking technology to truly understand how users interact with the system in real-time.

Future Work

There is a need to make Tails, and all technology focused on privacy, security and anonymity, more accessible to a wider population of users, as increasing one's control when on and offline is a growing concern in society, regardless of technical background. Future steps should investigate how technological advances can simplify all processes of Tails and how these simplifications will fair in the short and long run. Finally, a continuous improvement plan focused on constantly evaluating a technology's usability and iterating modifications from those findings should be adopted by developers in this field so their work can grow to benefit users of all backgrounds.

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