ABSTRACT
In this paper, we describe the design, development, and usability testing of a universal remote control user interface. This user interface needs to be easy to use and accessible by people who are mobility impaired, yet it can be used and adopted by the general public as well. The main hypotheses are that the aspects of familiarity, selective filtering, and freedom of choice will make the universal remote control user interface more easy to use. During usability testing, participants generally are satisfied with the user interface. However, the usability testing shows significant design issues. The three aspects in which the system design is based may not positively affect ease of use as it was intended. Increasing the user-device interaction speed will greatly increase the feeling of ease of use.

ACM Classification:
H5.2 [User Interfaces]: Graphical User Interfaces, Input devices and interaction techniques, Interaction styles

General Terms
Standardization, Human Factors, Design, Experimentation

Keywords
Universal user interface, universal remote control, adaptive user interface, accessibility

1. INTRODUCTION
In today’s urban world, it is almost impossible to go a day in the city without interfacing with any of the myriad of systems and devices that surround us everyday. From doors to crosswalk buttons, the selection of these systems and devices vary greatly. Each device has its own unique way to interact with it; the way someone operates a coffeemaker would be different than the way someone would operate a television set. Moreover, there are many ways to do the same task; a person in North America would flip a light switch up to turn on a light, while a person in the United Kingdom will flip a light switch down[5]. Unfortunately, even a light switch may be impossible to manipulate for someone who is physically disabled, or perhaps who just has his or her hands full at the moment. In these two cases, a universal remote control device would assist greatly. This paper attempts to address the issue of how people interact with devices through a universal remote control, the creation of a universal remote control user interface, and the analysis of the results after performing usability testing.

2. MOTIVATION
There are many people who are physically or mobility-impaired. In both United States and Canada, one in ten adults have reported as being physically or mobility disabled [2] [14]. Due to the large disability population, many human-rights groups were formed to pressure the government to make legislation changes to promote equality and increase accessibility in products and facilities [6]. For example, Microsoft is required to integrate accessibility features into the Windows operating system for the American (and Canadian) markets.

2.1 Accessibility and Universality
Universal accessibility is an active research area in both the academic world and in industry. Current universal access systems use input devices like oversized keyboards, key-guards, trackballs, sip-and-puff switches, magnification systems, head-tracking units or voice dictation often cannot be easily applied to devices in public spaces, and often rely on an external, personal controller. Output systems are normally tailored to the user’s needs. For example, if the user is both visually and mobility impaired, then the user can use a voice prompt for device operation. For those that are not visually impaired but cannot physically access a device, sometimes bringing the user interface directly to the user will be sufficient. Fortunately, the majority of devices today is state-based and thus employs the use of buttons, which can easily be represented by a graphical user interface. An attempt to address the latter category of people by designing a universal graphical user interface that can be displayed on a personal controller for universal remote controlling will be described in detail. The scope of this paper will focus on graphical user interfaces and touch-screens for user interaction.
2.2 Universal Remote Controlling

It is clear that accessibility is an increasingly important issue in the management of both personal and public facilities. The goal is to make things easier and more convenient for the user, and a good universal remote control system should be based on this reasoning. A universal remote control system often employs a three-prong system design. The three fundamentals are:

- Universal communication hardware
- Universal communication protocol
- Universal user interfaces

2.2.1 Universal Communication Technology

In the past twenty-five years, there has been much development in the realm of communications technology. Since the 1970’s, when Ethernet was being developed, stable communication network technologies expanded to include electrical wire-signals, infrared beams, fiber-optics, and wireless electromagnetics. Moreover, communication protocols are becoming more domain specific, from utility protocols like TCP/IP to control protocols like Zigbee and to personal level protocols like Bluetooth. Today, the wireless revolution made wireless devices virtually everywhere, as it is not uncommon to find cellular phones and watches equipped with 802.11 (WiFi) or Bluetooth wireless antennas. If universality is based on adoption rates, which are proportional to ubiquity of an item, then WiFi and Bluetooth can be classified as a universal communications technology.

2.2.2 Universal User Interfaces

The concept of a universal user interface is an area that has not been addressed in great detail. Again, the term “universal” here means the interconnectivity and interoperability of user interfaces across multiple devices. There are a number of attempts at creating standards to describe user interfaces, like Extensible Interface Markup Language, (XIML), Abstract User Interface Markup Language (AUIML), Alternate Abstract Interface Markup Language (AAIML), User Interface Markup Language (UIML), and W3C Device Independence Working Group (DIWG) [3][4]. The AAIML, featuring a descriptive structured user interface support, is a good match to the aims of the universal remote control. Moreover, the AAIML is part of a set of five standards in the American National Standards Institute (ANSI) that make up the V2 “universal remote console” system[4][13].

As mentioned above, the V2 universal remote console is based on a set of five ANSI standards that, together, will address the needs and scope of a universal remote control system. Although this system has strong credibility, it is not considered as the standard yet. There are other attempts from Stanford University and University of Hawaii with the Archimedes project [12] as well as Carnegie Mellon University with the Pebbles project [7]. Moreover, there are two patents filed in the United States that address the issues of a universal remote control [1][10]. However, these attempts have been proprietary. It is important to note that all of the mentioned systems attempt to deal with the various modality and functionality of the user interfaces by allowing the target device to describe the user interface as the manufacturer designed it. The variation between user interfaces may cause confusion for the users as they need to learn new interfaces for each device type. Although V2 allows for user interface templating as an attempt to increase usability, there is a requirement that all manufacturers must abide by a fixed interface layout with minimal stylistic and functional customization [13]. This is a deterrent for manufacturer adoption because of the limited customization and branding to distinguish the product from other competitors’ products [9]. Furthermore, these systems do not address the issue that users may want to use different user interfaces for a particular device, as a matter of accessibility or simply user preference [8].

3. UNIVERSAL REMOTE CONTROL USER INTERFACE

Although there is significant research in centralized automation systems, remote controls, and universal graphical user interfaces, there is no prior work on a universal remote control interface for the public domain. Although some protocols and standards, like V2’s XIML and AAIML, describe how to layout user interface objects universally on to a controller screen, only the AAIML standard addresses the possibility of developing common user interface layouts [13].

In the context of a universal interface, there is little research on developing a universal set of user interfaces that can be applied to any target device being controlled. A new universal graphical user interface system for universal remote controlling is being proposed in hopes to address certain issues.

3.1 Ethnographic Study

The first few steps in designing the proposed universal user interface is to observe how people interact with devices that they use daily, and to observe and analyze the issues of the current “universal” remote control systems that can be found in the consumer market today.

3.1.1 Daily Devices

Beginning with ourselves, we created a list of public and private devices that we commonly use in our day to day rituals. We also walked to a local shopping centre and observed people manipulating various devices as well. To find even more devices, we created various scenarios in which a mobility-impaired person in a wheelchair may have difficulty accessing devices daily. Table 1 below illustrates a few examples of our observations.

<table>
<thead>
<tr>
<th>Domain</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private</td>
<td>Alarm clock/watch</td>
</tr>
<tr>
<td></td>
<td>Doors</td>
</tr>
<tr>
<td></td>
<td>Lights</td>
</tr>
<tr>
<td></td>
<td>Thermostats</td>
</tr>
<tr>
<td></td>
<td>Phone/cellular phone</td>
</tr>
<tr>
<td></td>
<td>PDA/computer</td>
</tr>
<tr>
<td></td>
<td>Washing Machine</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>Doors</td>
</tr>
<tr>
<td></td>
<td>Lights</td>
</tr>
<tr>
<td></td>
<td>Crosswalk</td>
</tr>
<tr>
<td></td>
<td>Elevator</td>
</tr>
<tr>
<td></td>
<td>Button</td>
</tr>
<tr>
<td></td>
<td>ATM machines</td>
</tr>
<tr>
<td></td>
<td>ABM devices</td>
</tr>
</tbody>
</table>
Summarizing the results, it can be concluded that a typical person living in an urban area will encounter at least one if not many different types of devices daily.

3.1.2 Current Universal Remote Controls
The manufacturers of the universal remote controls we currently find in the stores today define the term “universality” to be the ability to control multiple devices of the same or various manufacturers. These “universal” devices are often proprietary and usually targets specific home-audiovisual devices and for those solutions-based controllers, some accessory systems like ventilation or air-conditioning system units as well. They tend to be cumbersome and are usually complicated to configure.

Of four randomly sampled universal remote controls that can be found in a local home electronics store, not one of them has an instructions guide less than 27 pages. These pages describe a complicated sequence of key-presses and many tables of device codes to properly configure the controller. Moreover, the manuals are written in small print (the approximate font size is 9 points or less), such that people with poor vision cannot properly configure the device even if the configuration process is simple.

Furthermore, these universal remote controls base their interfaces on providing virtually a one-to-one mapping of features to physical buttons, thus making the remote control enormous in size and complexity. Shrinking the size of the buttons would not make operation any easier, as people with limited motor skills and finger dexterity, or even large thumbs, may not be able to use these remote controls.

It was also observed that people that do not use the remote control often spend several or more seconds searching for the desired button to press. Data organization and layout play an important role in the acceptance and usability of a universal remote control user interface. A suitable user interface for this application should be easy to use and would be “universally controllable” as well as “universally controlling”.

3.2 Universal User Interface Design
Ease of use is dependent on familiarity, selective filtering and freedom of choice. We experiment on the concept of familiarity and allow users the ability to choose what they want to see or use.

3.2.1 Familiarity
It was noted that all the listed devices from the ethnographic study are state-based, and use or could use a graphical user interface employing the use of buttons. Dials, knobs and sliders are common mechanisms that could be implemented using buttons and text-based message feedback. Table 2 below identifies eight generic user interface button layouts.

<table>
<thead>
<tr>
<th>Button Layout</th>
<th>Directional</th>
<th>Functional</th>
<th>Selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left/right</td>
<td>Up/down</td>
<td>Number pad</td>
<td>Toggle switch</td>
</tr>
<tr>
<td>Up/down/left/right</td>
<td>Media (e.g.,</td>
<td>Stateless button</td>
<td>Selection list</td>
</tr>
<tr>
<td></td>
<td>Play, Skip,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rewind)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

People seem to use interfaces that they are more familiar with. As mentioned previously, the current work on universal remote controls stems from the idea of controller adaptability and ability to display various types of user interfaces, which may confuse users and require users to adapt to new interfaces for each new device to be controlled. Someone who is visually impaired would want to have a consistent user interface with button locations that remain constant [8]. This confusion is more pronounced when the layouts are dependent on international customs. In some countries, bank machine numeric pads begin with “123” on the top, while in other countries “123” starts on the bottom.

One of our hypotheses is that a universal remote control can be made easier to use by using standard button layout templates that reside on the user’s remote controller so that the user can operate any device using a familiar set of button layouts.

3.2.2 Selective Filtering
Positional organization, grouping, tagging, naming, and categorization are a few possible ways to provide selective filtering for the user. When a user of the universal remote control encounters and uses many devices on a regular basis, it may be necessary to filter the list of discovered target devices into a meaningful fashion. If the device names are not very descriptive, categorization and tagging may be needed to determine exactly what type of device it is and where the device is located.

Once the user has found the device in the controller user interface, the user can then interact with the functional features of the device. However, some devices, like a multi-function printer, may have a large selection of features such that further filtering is necessary.

Our second hypothesis deals with selective filtering using device categorization and functional feature hiding to make it easier for users to find the device and feature they want to interact with.

3.2.3 Freedom of Choice
The last hypothesis is based on an assumption that people who know exactly what they want to do would prefer to command rather than being told what to do. Preference stems from this issue; someone may want to use an up/down interface instead of a number pad. If we give users the choice of selecting which user interfaces they would like to use, perhaps the remote controller would be easier to use. To verify this hypothesis, we decide to integrate the idea of command and choice into the familiarity and selective filtering components.

4. IMPLEMENTATION
The universal remote control user interface is implemented as an application on an iPaq PocketPC PDA to simulate a typical universal remote control deployment. For the purpose of the user interface development and evaluation, the use of actual universal remote control protocol and communications hardware will not be used; however, the protocols will serve as a guide of what data types and typical messages can be sent. The user interface design will also create some other required message requirements that should be integrated or relayed through the protocol. Therefore, the implemented universal remote control user interface will use simulated target devices at the application-level to establish a functional user interface mockup.
It was identified that the user interface should be accessible by various input and output devices such as joysticks, touch screens, or voice dictation, but to narrow down the implementation scope, only the use of touch-screens will be used.

4.1 Structure
There are four basic aspects to the user interface system. First, the interface displays the target devices that the universal remote control can manipulate. Then, upon selection of a device, the interface will show the list of possible button layouts that is stored on the controller system. These layouts are used to manipulate the target device. After selection of a button layout, a list of device features that can use the selected button layout is shown. Finally, the selected button layout is displayed on the screen to control that feature, with text-based status messages to relay the particular configuration value or state of the target device.

Implementation of the three hypotheses mentioned in section 3.2 is achieved using two techniques. The aspect of ease of use through familiarity is represented by using pre-defined generic button layout templates (refer to Table 2) residing locally on the controller. Device categorization using a familiar instant-messenger metaphor and feature filtering using button layout selection are attempts at implementing both ease of use through selective filtering and freedom of choice.

During the initial design phase, the instant-messenger metaphor was chosen to represent the dynamic appearance and disappearance of many target devices that is made possible through contact grouping and online-offline statuses. The second choice was the use of the user interface layout selection as the criterion for feature filtering.

The best way to describe the system is to illustrate it with a top-down system walkthrough.

4.2 Device List
The user is first presented with a “contact list” that lists devices that the user has used before or new devices that the user can interact with. Figure 1 illustrates this contact list. Devices are placed into user-definable categories such as “computers” or “kitchenware”. When devices come into the vicinity, an “online notification” will appear, notifying the user that a device is in the communication range, and the device will be appear in the list as online (i.e., marked with an “O”). Devices that are not in the range will appear as offline (i.e., marked with an “X”). User can “categorize” devices for better navigation. Devices that have just been discovered are not yet categorized, so it will be listed under the “general” category. Categorization of devices allows users to “hide” devices that they are not interested in.

4.3 User Interface Selection
Upon selecting a device, the user is presented with “UI types” that the device implements. Instead of flooding the user with a complete list of features supported by the device, the user can select a specific UI type to filter out unneeded features. This step is shown in Figure 2.

The user interface selection has two purposes. The obvious purpose is to use the specified button layout to interact with a specific device feature. The second purpose is to filter a device’s functional features by what button layout the features support.

4.4 Feature Selection
Upon selecting a specific button layout, the user is presented with the filtered features list. Only the features that are associated with the selected button layout will be shown. In the case of Figure 3, the Up/Down interface was selected for a microwave, thus the user gets a filtered listing of features that implement the Up/Down interface, namely, “set timer” or “change power level”. Some functional features that are filtered out in this example are “auto defrost”, “multi-stage cooking”, and “keep warm”.

4.5 Control Interface
Upon selecting a specific feature, the user will be presented with the control interface that reflects the selected feature and button layout for the device. This is shown in Figure 4. The screen is divided into two parts: the control interface and the special menu. In the control interface, there are a status message area and a specific button layout. The special menu provides instant access to features that are important or do not map nicely into the available button layout. Regardless of the button layout selected, the special menu will always be available.
In another scenario, the user wishes to use the microwave using the number pad interface, so the user taps the “UI types” tab and selects the number pad interface. He then selects “set timer” feature (which the particular microwave manufacturer has not implemented yet) and the resulting control screen is shown in Figure 5.

![Figure 5. Control screen for microwave using number pad](image)

5. PERFORMANCE MEASURES

In order to evaluate how well the proposed universal user interface performs, usability testing is necessary to gauge the user interface’s ease of use and effectiveness.

The general idea being proved is that the universal remote control user interface should be reasonably easy to learn and easy to use. Operating it should be relatively similar to operating the real device. In particular, we will test the three hypotheses for the system’s ease of use, that is, using familiar button layout template, using an “instant-messenger” for categorization and filtering and allowing users the freedom to select a user interface button layout they prefer.

The remote control should be easy to learn in the sense that an average user should be able to operate the device after given a quick tutorial or through self-exploration. Operating the remote control should be similar to operating the real device in the sense that if it only takes one click to operate the device, then it should not take more than a few clicks on the remote control to achieve the same effect. The design goal is “1, 2, 3” – one click to select a device, one click to select an interface, and one click to select a feature. Under normal usage, it should not require more than 3 clicks to start operating a device.

5.1 Scenarios

To limit the interference of certain user interface ease of use enhancements, it was decided to divide the testing into four scenarios. Each scenario involves a person (the user) that would like to go into a building and get to his/her room on the 10th floor and watch a television program. Various twists are added to each scenario to demonstrate other aspects of the system and to keep the interest of the participants. Usability testing participants are required to execute all four scenarios.

One major concern with using multiple scenarios is that the results are highly sensitive to the learning factor. Once a participant has used the system once or twice, the speed at which tasks gets completed would increase. To reduce this effect, participants perform the four scenarios in random order.

5.1.1 Scenario 1

This testing scenario consists of users testing on a user interface that does not have any of the three hypothesis implementations. There is no device categorization, functional feature selection, nor button layout selection. This scenario is the baseline implementation designed as a point of reference for comparison.

5.1.2 Scenario 2

The second scenario involves a user interface with device categorization. However, functional feature selection, and button layout selection are not implemented. This scenario evaluates the performance of the device categorization.

5.1.3 Scenario 3

Device categorization and functional feature filtering is used in this scenario. Feature filtering is implemented without selection of the user button layout to minimize the amount of variables introduced to the system.

5.1.4 Scenario 4

The final scenario utilizes all the designed user interface ease of use enhancements. Participants testing with this scenario will observe the combinations of the three hypotheses, and it is predicted that the participants will find this system easy to use.

5.2 Measurements

Several quantitative evaluation measurements will be recorded. For each task, the time it takes to complete each task and also the “clicks” (what the user clicked) will be logged for each user. If a task takes a long time to complete or if there are an excessive number of clicks, then that may indicate poor ease of use. The log file will parsed after the evaluation for further data analysis. Since the participants performed the scenarios in random order, the completion times for a certain task are then averaged between the four scenarios to reduce the effect of the learning factor.

After the participants have completed a scenario, they would fill out a questionnaire prompting for qualitative feedback on the user interface compared to manipulation with an actual device. This questionnaire gauges the participants’ device usage comfort. Key questions asked in the questionnaire would be their opinion on the user interface’s ease of use and effort, device searching, the usefulness of the button layout selection choice, and the button layout ease of use.
5.3 Participants
The audience scope of the universal remote control targets the mobility impaired as well as the general public. Although the current demographics show that the majority of high-technology consumers and adopters are in the 15 to 35 age group [10], the list of the twelve volunteer participants ranges from 20 to 59 in age. Though most of these participants are students, a few of these participants represent other areas. One participant is a professional writer and two other participants are industry experts involved in developing assistive technologies for the mobility impaired. The two industry experts in assistive technologies represent the mobility impaired in the usability testing.

The participants will be divided into 2 groups. Though everyone will be given a brief walkthrough of the user interface, one group of 5 participants will be given a set of the four scenarios that have explicit instructions on what to look for, how to find it and how to use it. The other group will be given a scenario set with minimal instruction in the scenario descriptions. The purpose of dividing the testing into two test groups is to remove the effect of comprehension and cognition times spent understanding the scenarios.

6. RESULTS AND DISCUSSION
The usability testing results are divided into two sections. The first section involves the quantitative testing information, while the second section handles the qualitative feedback gathered from the questionnaire.

6.1 Quantitative Results
The average time and number of clicks a participant spent on the elevator task in each scenario is illustrated in Table 3.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Avg. Time (secs)</th>
<th>Min Time (secs)</th>
<th>Max Time (secs)</th>
<th>Avg. num. of clicks</th>
<th>Min num of clicks</th>
<th>Max num of clicks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>81</td>
<td>40</td>
<td>132</td>
<td>8.75</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>76</td>
<td>31</td>
<td>171</td>
<td>8.5</td>
<td>8</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>76</td>
<td>23</td>
<td>127</td>
<td>10.25</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>4</td>
<td>76</td>
<td>26</td>
<td>247</td>
<td>8.25</td>
<td>8</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 3. Elevator task performance

The average time and click metrics are used to minimize the effect of the learning factor on the results. There were instances where the user was lost, resulting in excessive number of clicks. This may happen when the user first started using the system, early in his/her stage of learning. This does not necessarily suggest that the user interface design is bad, but nonetheless that is a possibility. Another possibility of excessive number of clicks could be caused by user doing self-exploration. One interesting thing to note is that the minimum number of clicks for all four scenarios are the same, suggesting that it is possible to learn the system and minimize the effort (optimize efficiency). In terms of the average number of clicks for each scenario, they are quite close to the minimum number of required clicks. The difference between the largest average value and the minimum number of clicks is within 30%.

Similarly, for the time measurement there are many factors that influence the accuracy of the data. For example, one participant had particular difficulty understanding the scenario, which led to an unusually high task time. Similar to the average number of clicks of the four scenarios, the average time of the four scenarios are very close, with the exception of one value. Unlike the measurement of number of clicks, the measurement of time is greatly influenced by the user’s ability to understand and focus. For example, if the participant loses focus and starts wandering around, or if the user takes a long time to read and understand the instructions, then the time measurement will include many idle times. Looking at the maximum time, it suggests that scenario 4 is the hardest to start with as the first scenario, followed by scenario 2, 1, and 3. Looking at the minimum time, it suggests that scenario 3 is the easiest to start with as the first scenario, followed by scenario 4, 2, and 1. Interestingly, scenario 2 and 3 are ranked similarly in the previous two observations, with scenario 1 and 4 trading places. This shows that there is a big difference between scenario 1 and 4.

6.2 Qualitative Results
Below are some pie graphs representing the data collected from the questionnaire.

Figure 6. Result of “this user interface is easy to use”
As shown in Figure 6, around 58% of the participants agree, or strongly agree, that the user interface is easy to use.
As shown in Figure 7, around 83% of the participants agree, or strongly agree, that finding the devices to control is easy.

As shown in Figure 8, around 75% of the users agree, or strongly agree, that the target device UI button layouts are easy to understand and use.

As shown in Figure 9, around 67% of the users felt that the different UI selections were useful.

Overall, the majority of the users are satisfied with the UI.

6.3 Discussion
For purposes of comparison, participants were asked to list a few things they dislike about the current remote control interfaces. A few participants mentioned that the current remote control devices have too many buttons on them; moreover, finding and pressing the buttons on the remote control is difficult to perform. This particular participant feedback supports one of the motivations and goals for this user interface system.

6.3.1 Button Layout
Ten out of the twelve participants rated the predefined user interface button layout to be easy to understand and use. The only main comment against this is regarding a target device implementation design decision, where the “power” button for a television set is displayed in the “special” list only. As this is an implementation design issue, a solution is to place the “power” button under the “toggle switch” user interface. After suggesting this solution to the participants who commented on it, they were satisfied. An area for concern raised by both industry experts is that graphical user interfaces are not accessible to people with visual impairment, where a text-based, screen-readable interface would be preferred. However, this was to be expected, as the scope was limited to graphical user interfaces only.

6.3.2 Selective Filtering
Seven participants find the device categorization did not help in device searching. However, most participants agree that the “instant messenger” metaphor was unique and conveyed the sense of “dynamicity”. Unfortunately, all users commented that getting to the device list page after manipulating a device is not intuitive.

One of the industry experts commented that the device categorizations would work well when users would encounter many devices in a small area; however, he commented that the use of short-range wireless technologies would create a physical device filtering, as devices out of range would not be detected, so that it was not necessary to display offline devices at all. The whole idea of categorization created more complication than the benefit received from it. If no categorizations were used, the user interface would be more easily navigated for device selection. In a public space, like on a city sidewalk, the number of controllable devices in a short distance (under 10 metres radius) is small. Since there are not many devices in the public space, the categorization component of the second hypothesis is not a suggested enhancement for use in public spaces.

Although the simple four-screen filtering design is simple in concept, it is not simple in use. Once the user becomes familiar with the particular device being controlled, the user should be able to “shortcut” his or her way through the process. Another way to improve this four-screen concept is to enable the use of a default button layout with the ability to store user preference.

Were the different UI selections useful?

Figure 9. Result of "were the different UI selections useful"
6.3.3 Freedom of Choice

About two thirds of the participants thought that the UI selection choice was a unique as well as a useful idea. Though originally designed for improving ease of use, all the participants commented that the button layout selection choice was non-intuitive; they all expected to select the user feature before selecting the user interface. When the participants were asked to explain this particular view, they all explained that they expected to be told immediately what interface to use rather than be given the option. However, after some discussion with a few participants, it was determined that if they were able to select the feature first before selecting the button layout, they would be more comfortable using the remote control user interface. From this response, the results of the third hypothesis are inconclusive.

7. CONCLUSIONS

From the results of the usability testing, people were generally satisfied with the user interface. However, a few of the assumptions made during the design phase of the system overlooked the simplicity requirement of a universal interface. People have come to expect that the user interface is static and feel uncomfortable making choices; moreover, they would rather adapt to the current device than make explicit decisions.

A major lesson learned from usability testing confirms that the ease of use is not dependent on familiarity, information filtering and freedom of choice; it is fundamentally dependent on the ability for users to interact with a device quickly. Simplicity and freedom of choice are methods to accomplish ease of use. Systems should be designed so that the user interaction speed would be increased.

8. ACKNOWLEDGMENTS

We would like to thank Dr. Fels and Dr. Michelson for guidance in developing this system. Special thanks go to Harry Lew and Dan Leland from the Neil Squire Society, who have given valuable background information and usability feedback.

9. REFERENCES


