Usability and Appeal of a 2D versus 3D Linux Operating System

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Abstract

Gauging the interaction between a piece of technology and the user is of critical importance for engineers and developers. This experiment compared the usability and appeal of a 2D versus 3D Linux desktop. A within-subjects design was used which allowed participants to experience both the 2D and 3D desktop as well as two different task sets. No significant difference was found when examining the length of time it took participants to complete the tasks for each desktop. Participants preferred the 3D desktop over the 2D desktop only if they experienced the 2D desktop first. This difference in preference can be explained through cognitive load.

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When one thinks about the variety of products and services that we interact with on a daily basis, it can be astounding to think of all the time and energy that went into the design of these products. This is why engineers spend so much time designing interfaces not only for physical objects but virtual ones such as computer desktop environments. The U.S. Department of Health and Human Services even maintains a website on developing usable and useful websites (U.S. Department of Health and Human Services, 2007). This website provides a wealth of tips on determining exactly what usability is and how to gauge its effectiveness. People often get confused using websites because of poorly designed menus and navigational tools. Menus are hard to design because users want to quickly gain access to the information they need. A link on the menu might lead the user to an unrelated topic and thereby frustrate them. Links need to be easy to read and have relevant and concise titles. "Don't Make Me Think" (2000) is the title of Steve Krug's book on website usability. He found that users viewing a website do not read it left to right like a book; they scan the page and look for bold titles and words that match what they are interested in. His point can be boiled down to this: websites should be concise, self-explanatory, and obvious.

Fitts' law is a "usability law" that is unfortunately under-utilized in software applications. Its premise is that, "the time to acquire a target is a function of the distance to and size of the target" (A Quiz Designed to Give You Fitts, 1999). Click-able labels or buttons need to be large and distinguishable from other items on the screen. Another usability feature employed in some operating systems is the four corners of the screen. Users can "throw" their mouse to each corner to access some feature. This is quick and easy to perform. In Windows XP, the start menu is located in the bottom left corner of the screen for exactly that reason. The start menu is frequently used, and the developers wisely put it there for easy access.

With Microsoft, Apple, and various Linux distributions all competing for business, computer operating system market share information is an important statistic. A Linux distribution is a specific way that the software is packaged together with the base kernel. It is fairly easy for people to make their own Linux distribution and there are literally hundreds available online. Based on polling data, some version of Microsoft Windows is being run on about 90% of all desktop computers, Apple has Mac OS 9 and OS X on about 4%, while the rest are made up of Linux users and other operating systems (Linux Desktop, 2004). The user interface for Windows Vista has received a complete overhaul. The Apple development team has also been working on major graphical advances and changes for Apple OS X. This emphasis on accelerated 3D graphics has been a huge step for all major computer operating systems. The major question is whether these graphical enhancements help the user interface and make the system easier to use or whether they are just "eye-candy". These 3D graphics may look pretty, but they may not actually provide any usability improvements.

Computer Desktops and Usability

Previous research on human-computer interfaces has demonstrated the utility of empirically examining the usability of software. For example, Park, Han, Park, and Cho (2007) empirically examined computer menu systems. Adaptive and adaptable menu systems were compared to see which one was more usable in terms of both decreasing task time and the number of errors as well as user satisfaction. An adaptable menu allows the user to rearrange the items according to his or her preferences. An adaptive menu on the other hand changes dynamically to reflect the top items that have historically been used by the user. The adaptable menu was shown to be better in terms of both usability and user preference than the adaptive menu system.

Research Design

The present experiment examined the usability and appeal of 2D and 3D Linux desktops. Linux, an operating system similar to Windows XP or Mac OS X, is free and open source software.

Linux development was started in 1991 by Linus Torvalds at the University of Helsinki in Finland (Rupley, Kaven, & Steinhart, 2005). All the source code and inner workings of the operating system are freely available for anyone to modify and supplement. This is made possible by the GNU General Public License (1991). This license allows for full access to the source-code. Any additions or changes that are made by individuals or companies are required to be open and under the same license. In this way, the license keeps the entire work free and open, including any future improvements. People from around the world contribute code and expertise to Linux. All the pieces are then put together to form a complete operating system distribution. There are a wide range of Linux distributions put together by groups and companies, but the underlying framework of the Linux kernel remains largely the same. The development model of open source software is appealing to developers because they can obtain help and support from people all over the world. Users enjoy Linux because it is a free alternative to other operating systems. While there has been no previous research comparing 2D and 3D Linux desktops, there has been research comparing other software applications that are 2D and 3D.

Research comparing 2D and 3D web-browsers has shown that participants using the 3D browser were able to complete tasks faster (Risden, Czerwinski, Munzner, Cook, D. 2000). This research is important because it shows that the 3D browser was a more usable application because of the decrease in time required, thus the increase in usability. The researchers compared a traditional 2D browser to that of an XML3D browser that incorporates a tree-like structure of representing information in a 3-dimensional view. An example screenshot of the XML3D browser taken from their paper can be seen in figure 1.

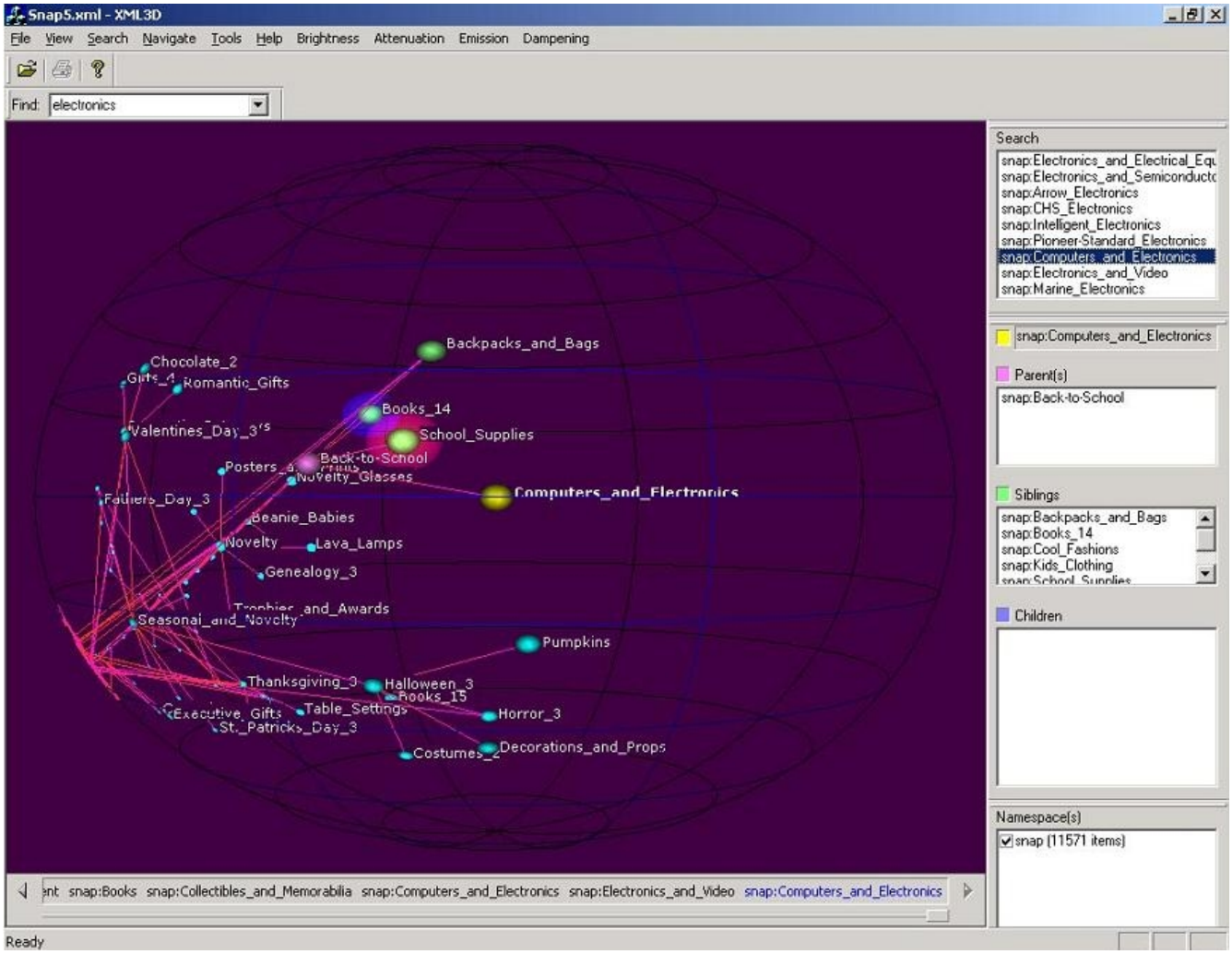

Figure 1. XML3D browser screenshot.

It is important to examine the effects of these 3D interfaces because there has been little work examining them in the latest Windows and Apple products and almost no empirical experiments involving the ongoing development of these 3D interfaces in Linux. The 3D Linux desktop was expected to be more usable and appealing than the 2D Linux desktop. A desktop is deemed more usable when it takes less time to complete tasks. A highly appealing desktop is one that the user deems as being aesthetically pleasing and exciting to use from a visual standpoint.

Method

Participants

All 9 men and 36 women experienced both the 2D and 3D desktops. Men *(M=4.51, SD=1.49)* were found to have a slightly higher tech experience level than women *(M=2.54, SD=1.21).* This tech experience was found by averaging the answers on being able to fix their computer, hardware upgrades, knowledge of programming languages, and previous knowledge of Linux. Windows XP was the most popular operating system used by the participants followed by Windows Vista as shown in Table 1.

Table 1

Frequency of operating systems used by participants.

Operating Systems

Operating System	Frequency	Percent
Windows XP	30	66.7
Windows	3	6.7
Windows Vista	9	20.0
Mac OS10	2	4.4
Mac OS9	1	2.2
Total	45	100.0

Materials

After answering a few demographic questions, participants answered four questions (see Table 2) about their prior operating system on a scale of 1 (no/bad) to 10 (yes/good). A reliability analysis was performed on this grouping of questions and they were highly related (Alpha=.82). Because these items had adequate internal reliability, these questions were averaged together to form one variable as were other question sets. Alphas ranged from the lowest for technology experience (Alpha=.69) to 2D desktop experience (Alpha=.75) all the way to the 3D desktop experience (Alpha=.81). The full listing of questions can be seen in Table 2.

Table 2

Items used to assess prior operating system, tech experience, desktop evaluation for both 2D and 3D, and post desktop evaluation.

Construct	Items
Demographic	Do you own a computer? What operating system do you use the most? How willing would you be to switch to a completely different operating system that is new to you?
Prior Operating System	How pleased have you been with the operating system you use the most? How would you rate the appearance of the operating system that you use the most? Would you say the operating system you use the most is enjoyable? Is the operating system that you use easy to use?
Tech Experience	If there was something wrong with your computer, for example, you got a virus, would you be able to fix it yourself or would you need to have someone help you? Does opening up a computer case and upgrading components scare you? Do you know any programming languages? How familiar are you with Linux?
Desktop Evaluation	How would you rate the appearance of this (2D/3D) Linux desktop experience? How would you rate the ease of use of this (2D/3D) Linux desktop experience? Was it easy switching between applications in this (2D/3D) Linux desktop? Are the image icons, colors, placement of buttons, and so on intuitive? How would you rate the (2D/3D) Linux desktop as compared to the operating system you use on a regular basis?
Post Desktop Experience	What was more appealing, the 2D Linux desktop or the 3D Linux desktop? What was more user-friendly, the 2D Linux desktop or the 3D Linux desktop? Would you be willing to try the (2D/3D) Linux desktop as your main operating system after this experience? Which operating system do you like more, the (2D/3D) Linux desktop or the one you use on a regular basis?

Apparatus

Two Dell desktop computers were used by the participants. The 3D desktop was an all-in-one Gateway DS Profile 4MX with an Intel 2.6 GHz processor with 256 MB of RAM and a 64 MB GeForce4 MX 440 AGP graphics card running the latest proprietary Nvidia binary drivers. The 2D

desktop had a Pentium 4 – 2.4 GHz processor with 256 MB of RAM and a 128 MB Intel integrated graphics card. Ubuntu 7.04 "Feisty" was installed on each of the computers along with the latest build version of Compiz Fusion.

Procedure

Participants were randomly assigned to one of two orders of desktops and one of two orders of task sets. Participants experienced either the 2D desktop first then the 3D desktop or the 3D desktop first then the 2D desktop. Half of the participants who received the desktops in each of the different orders completed task set #1 and then set #2. The other half completed task set #2 before task set #1. In this way participants were assigned to one of four conditions in order to counteract temporal and assignment issues.

An online survey was administered first to gather information on their technical expertise, prior desktop experience, how happy they were with their current desktop, and how they would rate their current desktop. Participants watched a short video over the basics of the Linux operating system. They were then timed while attempting to complete a set of tasks for each desktop (e.g., creating a document, navigating folders, deleting files) in order to empirically gauge the usability of the system. A full listing of the tasks required for both task sets can be seen in Table 3.

Table 3

The full listing of tasks for each of the two task sets.

Task Set #1
Task #1 -Launch the word processor Open Office. -Type a sentence or two -Save the file in your home directory, you can give it whatever name you wish -Close Open Office -Delete the file you just saved -Empty the trash to permanently remove the file
Task #2 -Change the desktop background to an image in your home directory in the Pictures folder

Task #3
-Open the Calculator application, Firefox application, and Terminal application
-Switch to a different virtual desktop
-Open the game Mines
-Move the Mines window to the virtual desktop with the Calculator, Firefox, and Terminal applications open
-Practice resizing and moving the applications
-Close all applications

Task Set #2

Task #1
-Open the Rhythmbox application and import the Music folder in your home directory
-Close Rhythmbox

Task #2
-Search for the file deleteme.txt
-Delete the file
-Empty the trash to permanently remove the file

Task #3
-Open Tomboy Notes and make a note of something you need to do later today
-Switch to another virtual desktop
-Open the game Soduku and the application Movie Player
-Hold CTRL and ALT, and left click and drag the mouse and change virtual desktops to a blank one
-Switch back to the virtual desktop with Soduku and Movie Player open
-Move the Soduku window to the bottom left corner of the screen and resize the Movie Player so it's small and put it in the upper right corner of the screen.
-Close all applications

An example of the 3D cube that can be rotated to view different virtual workspaces can be seen in figure 2. Virtual desktops can be used to separate tasks and keep windows organized. For example, in one virtual desktop you could be working on a word document and in another browsing and managing files. These virtual desktops were something that people commented were extremely useful in debriefing.

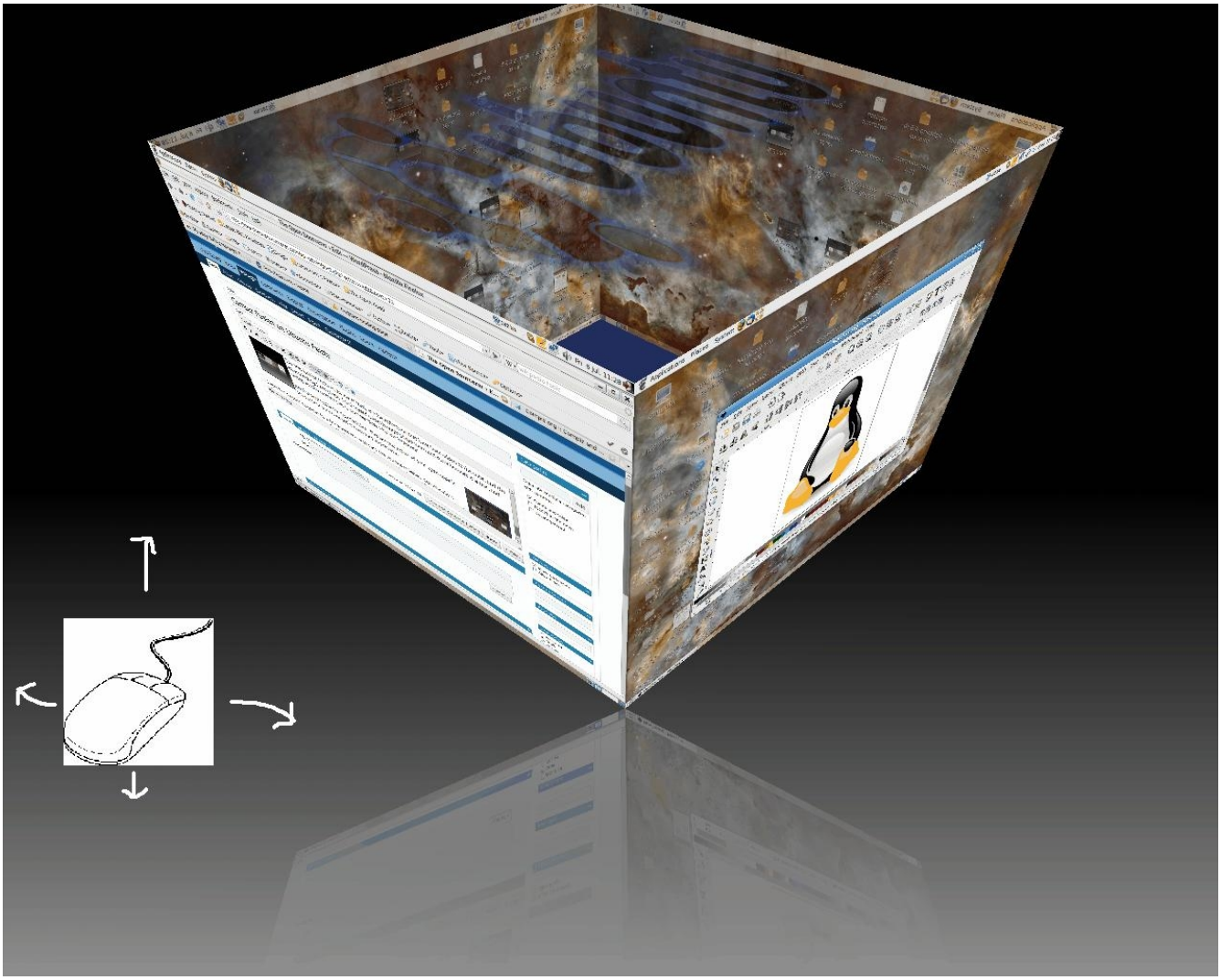

Figure 2. 3D cube showcasing different virtual desktops.

The “wobbly windows” 3D effect is another small touch that happens when windows are dragged around the screen. A still image of this can be seen in figure 3.

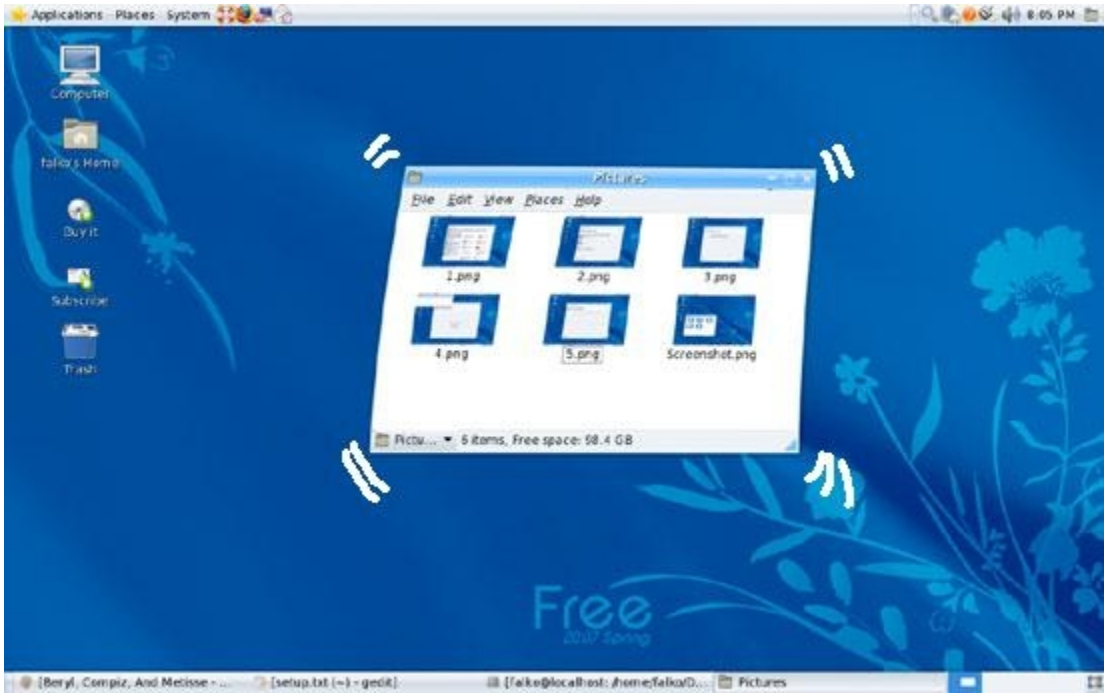

Figure 3. “Wobbly Windows” 3D effect.

After using each desktop, participants rated the attractiveness and appeal of the desktop on a series of 10 point Likert scales. After the desktop experiences were finished, participants watched a final video showcasing the more entertaining aspects of the 3D desktop. These include features that would not be considered usability enhancements. Some examples from the video were water effects, fire painting, and a 3D cube showing each of the virtual desktops with fish in the middle simulating an aquarium. An example of the fire painting can be seen in figure 4.

Figure 4. 3D fire painting example.

Results

A 2 (2D versus 3D) x 2 (Order of Desktops) x 2 (Order of Task Sets) mixed factorial ANOVA was used to compare the number of seconds it took participants to complete the tasks. As seen in Figure 5, participants completed whichever task set they did first (M=490.06, SE=19.57) slower than the set they completed second (M=385.87, SE=16.77), $F(1, 41) = 25.7$, $p < .001$. No other main effects or interactions were statistically significant, all F values (1, 41) < .709, ns.

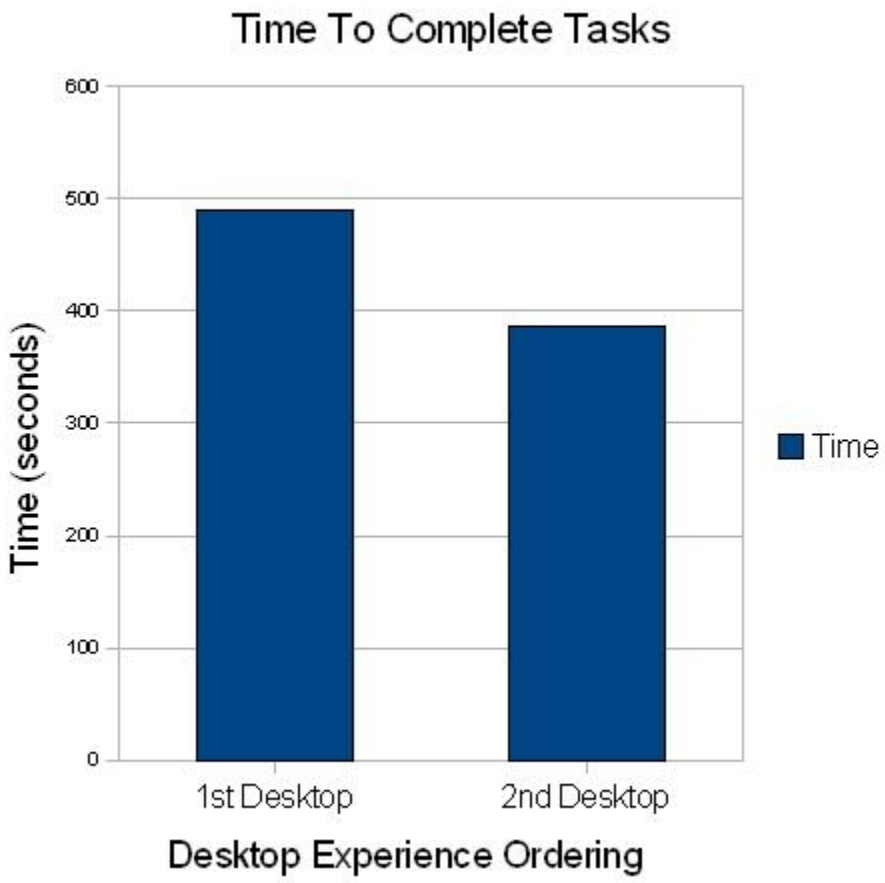

Figure 5. Average time to complete tasks for the first and second desktops experienced.

A second mixed factorial ANOVA was used to compare the overall evaluation of the desktops. As can be seen in Figure 6, participants preferred the 3D to the 2D desktop, $F(1, 41) = 4.89$, $p < .05$; however, this main effect was modified by a significant interaction, $F(1, 41) = 5.00$, $p < .05$. Participants only preferred the 3D desktop if they experienced the 2D desktop first. No other main effects or interactions were statistically significant.

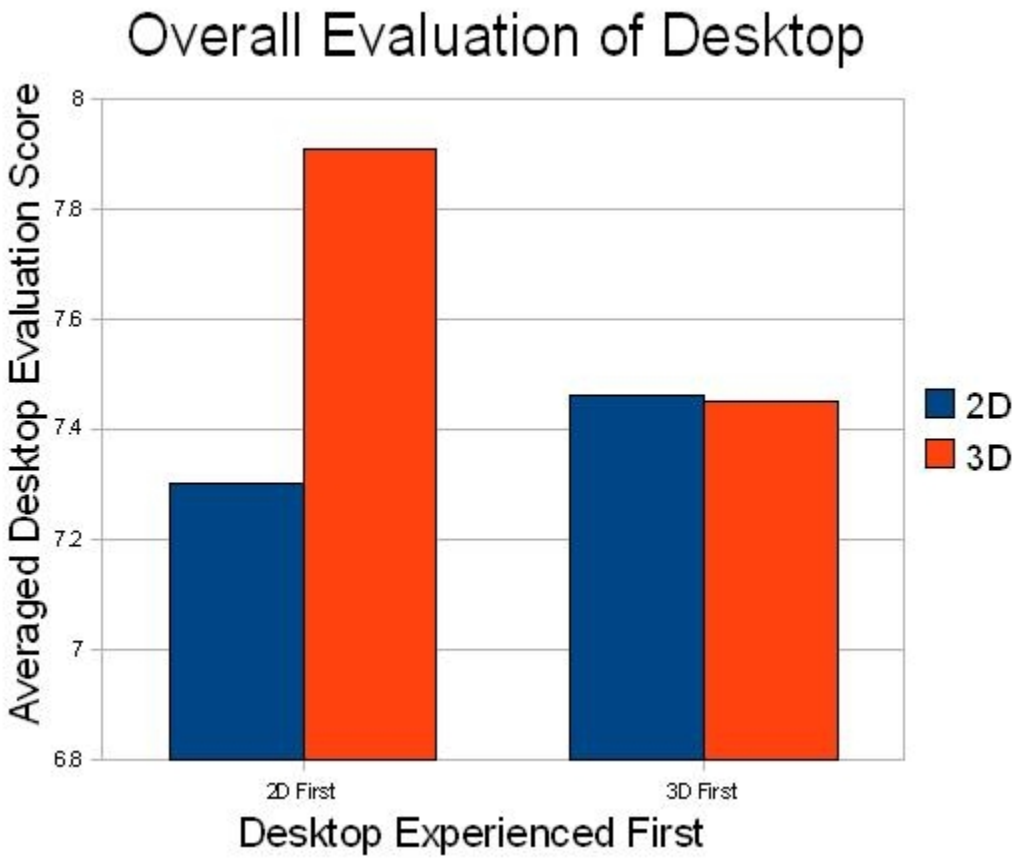

Figure 6. Participants preferred the 3D desktop more only if they experienced the 2D desktop first.

Discussion

The results support the hypothesis that participants would like the 3D desktop more than the 2D desktop based on appearance and the appealing visual qualities, however, the 3D desktop was not found to be more usable. Participants completed whichever task set they did first slower than the one completed second. This is a rather novel result considering the within-subjects and ordering of the task sets were setup in the design of the study to prevent this. At an intuitive level, it makes sense because participants needed time to get used to the desktop and learn the interface. Participants preferred the 3D to the 2D desktop if they experienced the 2D desktop first and equally if they experienced the 3D first. The aforementioned interaction can be explained through cognitive load theory (Mayer, & Moreno, 2003; Reed, 2007). Cognitive load refers to the theory that people only have a limited amount

of attention and focus. If the person is given too much to do or feels overwhelmed, they will not be able to parse all of the information and their performance will suffer.

Participants may have used the first experience to get used to the desktop and the semantic level of the interface leaving them little cognitive processing available to appreciate the visual 3D effects. This is supported by the fact that participants were slower on whatever desktop they experienced first than the second desktop. It may be that the 3D desktop actually is more usable, but that this effect would only appear with experienced Linux users who have gotten over the initial learning curve. As was previously mentioned, the Risden study found that participants were able to complete tasks faster when using the 3D browser (Risden et al, 2000). However, the participants in their study were experienced software developers who were probably more familiar with the interfaces and design paradigms of applications than the average user. Further studies examining participants who are experienced Linux users might show that the 3D desktop is more usable.

That being said, it is also possible that there is no usability advantage by using a 3D interface. From a practical standpoint, many of the 3D effects can be seen as only "eye candy". They are interesting to look at but they may provide no real benefit to increase productivity. As more users begin to use computer operating systems that have 3D effects it will be interesting to see what their opinion is. Just as usability can be examined by looking at the speed at which a user completes tasks, it alternatively could be examined by plainly asking the user what they thought about the experience. While not as discrete as a numerical value, these explanations could provide insight into changes that could be made or usability issues that do not deal with speed and productivity.

Examining cognitive load while using computers has even been studied in online multiplayer games. Massively Multiplayer Online Role-Playing Games also known as MMORPGs were studied in an attempt to understand the cognitive load factors that crop up while playing (Ang, Zaphiris, & Mahmood, 2007). They found that there was significant cognitive load even for the veteran players

because of the multitasking and variety of objects that have to be kept in memory. However, this cognitive load is what makes games interesting and fun. If there was no cognitive load in computer games there would not be any challenge. That being said, too much cognitive load makes the game too difficult and the authors give many suggestions as to ways that cognitive load can be decreased specifically in MMORGPs. Hopefully these strategies for reducing cognitive load can be generalized so that they apply to any computer application.

The greater appeal of the 3D desktop may help new users through that learning curve. Many participants reported that they enjoyed the study and some even mentioned that they would like to try the Linux desktop on their own computer. Given the growing popularity of Linux, it is important for Linux contributors to continue making strides in advancing the technical prowess of Linux as well as the usability and ease of use. A new user may only give Linux a few hours of use before deciding whether to stay or switch to another operating system. Given the steep hardware requirements for running these new operating systems and 3D graphical enhancements, the user is often paying the price for this "latest and greatest" technology. The latest computer hardware is always very expensive and new users may not want to spend large amounts of money on this just to get some flashy 3D effects if it does enhance the usability of their desktop experience.

Obviously, if the participants would have had more time with the desktops and understood the usability differences between the 2D and 3D desktops, it is possible there could a significant usability difference on the side of the 3D desktop. This experiment was not only a test of usability but also learning since almost all participants had no experience using Linux prior to the experiment. If the learning process could be factored out in a future experiment this could lessen the cognitive load.

The major downside to this experiment was the fact that time was only recorded for the entirety of the tasks. There was no timing done on specific tasks in each of the task sets. Having more precise and defined values here might have been interesting to look at to see if there were specific tasks that

were easier or harder for participants. Most of the participants also got stuck at some point and asked for assistance. Since every individual is different in the amount of time or patience they have when working on a task, this is an additional variable that should be more carefully examined in future experiments.

That being said, this experiment was important because it shows that there is significant cognitive load associated with learning a new computer operating system interface. Finding ways of alleviating this by changing the interface to make it less demanding or easier to use as well as finding ways to decrease cognitive load at the user level could hopefully combine to create an acceptable level of learning for a broad audience.

This also has implications for future research involving cognitive load and appreciation. People may enjoy or like something less because they are under cognitive load. Given the scarcity of research in this area, an experiment should be implemented to test these variables. Considering the fact that people are under cognitive load all the time, a successful test showing that these two variables are related would have a drastic influence on a wide variety of social situations. For example, advertisers would want to make sure their product was being presented or experienced under little cognitive load. On the flip side, there may be some people who enjoy being under cognitive load because they view it as a major challenge. These are some major questions that could be answered by researchers.

It is clear that more research needs to be done involving the testing of desktops. Given the large amount of work done by businesses and individuals on computers every day, it has become a ubiquitous tool in the workplace. An important question that should be addressed in future research is the potential that creating a more usable desktop could increase productivity as well as decrease worker fatigue through the use of the visually appealing desktop. Usability is an important factor that not only developers need to be aware of but also any engineer that is designing a product for a market.

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Additional websites that may be of use for those interested in Linux usability:

http://developer.gnome.org/projects/gup/references.html

http://developer.gnome.org/projects/gup/usertesting.html

http://developer.gnome.org/projects/gup/ut1_report/report_main.html

http://hcibib.org/

http://openusability.org/

http://programming.newsforge.com/article.pl?sid=04/07/07/1640244&tid=25&tid=2&tid=26&tid=31

http://tango.freedesktop.org/

http://usableweb.com/

http://www.betterdesktop.org

http://www.linux-usability.de

http://www.relevantive.de/gimp/report/results_usabilitytest_05.04.html

http://www.relevantive.de/Linux-Usabilitystudy_e.html

http://www.useit.com/