An Investigation on the Merits of the Keyboard and Mouse

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.
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Introduction

Current smartphones are magnitudes more powerful than the computers that sent us to the moon in 1969 and even the preeminent supercomputers of the 1980s. They also demonstrate a much more efficient use of space and resources. It is clear that computing technology has advanced in leaps and bounds over this period of time, and it remains one of the fastest growing and evolving fields to this day. Unlike the hardware that allows these machines to function, the primary way in which we interact with desktop and laptop computers has basically remained unchanged over this period, even though they have become vastly more compact and capable. Why is this the case? For my STS research paper, I focus on the merits of the standardized keyboard and mouse computer input setup, as well as potential pitfalls or improvements to be made on these input devices. I will first discuss the inception of these devices and the process behind their adoption, followed by an examination of existing and future alternatives to these devices. I will then synthesize these findings in the context of the Social Construction of Technology framework and discourse analysis, along with the results of some of my own surveying. These topics are important to consider because the influence of computers on our world is only increasing, and it is important to understand how we interact with them.

Creation and Development

The earliest predecessor of the modern computer keyboard was, unsurprisingly, the typewriter. While the true inventor of the typewriter is disputed, the first patent for a competent and somewhat modern design was awarded to Christopher Sholes in 1868 (Bellis 2020). However, this typewriter did not use the current QWERTY layout we are familiar with today, which Sholes and a partner later patented in 1878 in order to reduce contact and friction in the inner mechanical workings (Bellis 2020). Other layouts attempted to later contend with the QWERTY layout by rearranging keys to reduce the movement of the fingers away from the home row and thus provide more efficiency. Two of the most common, the Dvorak and Colemak layouts, boast 57 and 61 percent of keystrokes on the home row respectively, which are impressive when compared with the 32 percent home row usage of QWERTY (Weinert, 2017, p. 2). As computers began to evolve beyond punch cards, they were slowly able to incorporate more and more aspects of the typewriter keyboard. This culminated in the 1964 Multics computer system by MIT, Bell Laboratories, and General Electric, which included a video display terminal (VDT) that allowed typed characters to be shown on the screen (Bellis 2020). The Multics system represents the first modern instance of the keyboard and display combination which we use today.

Since then, the main evolution of the computer keyboard has come in the form of different types of key switches. The liner switch design, which is present in mechanical keyboards, allows the key to travel in a longer downward path to the sensor where it is then returned to the original position by a spring. This requires some amount of force to be used in order to compress the spring, depending on the model. These come in variations such as tactile or clicky that provide slightly different user experiences. The main alternative, the rubber dome, allows the key to travel a shorter distance and tends to be quieter by comparison. This design is used in Apple keyboards and has become commonplace in laptop keyboards across the industry (Weinert, 2017, p. 2).

In terms of the computer mouse, it was invented around 1963 by Douglas Engelbart and Bill English. Engelbart originally conceived of the idea as a way to measure a two dimensional chart before applying the concept to selecting objects on a computer screen. The original design consisted of a button and two wheels at 90 degree angles to each other, and the measurement of the rotation of the wheels allowed the computer to simulate (and more appropriately move) a cursor on the screen. This version was paired with an item called a Chordset, which was a small pad with additional buttons that acted as shortcut keys, in order to benefit the mouse in its original job of text editing. English sought to further the development of the computer mouse at the company Xerox's Palo Alto Research Center, where the design was adapted to include a single steel ball and was used with a Graphical User Interface (GUI). The mouse was finally made commercially practical on a large scale by Apple, when they introduced a much cheaper and more reliable version alongside their Lisa computer in 1983. Yet, Apple and Microsoft did struggle with widespread adoption at first, and they included numerous software training programs and instructional texts regarding the mouse for over a decade to follow (Atkinson, 2007, p. 47-54). With touch screens becoming more popular in recent times, a number of mouse designs in the past decade or so have sought to incorporate some touchscreen functionality into the mouse, to varying degrees of success. These "touch mice" as they are called allow users to perform actions such as pinching, sliding, tapping, and swiping, alongside the traditional mouse functionality (Chou, 2016, p. 2876). The most well known example is the Apple Magic Mouse.

Alternatives

When it comes to the traditional computer keyboard, there are not many true alternatives. The level of functionality and the ease of use provided by the typical keyboard cannot be ignored. In terms of hardware options, there are split keyboard designs which tend to be functionally the same as a traditional keyboard. The split keyboard designs, however, generally attempt to improve ergonomics and comfort for users, especially over extended durations. They also tend to offer more customization in order to cater to the workflow of the user. Another alternative, called the CharaChorder, has garnered media attention. This radically different design consists of 18 5-way tactical switches that allow for multi-directional inputs and pressing. The device allows for chorded entry of letters (inputting multiple at once) in order to greatly improve typing speed. The team claims that, with practice, the average user can achieve typing speeds of approximately 250 words per minute, as compared to the reported average of 40 words per minute with a traditional keyboard (CharaChorder *About*).

Speech-to-text is also a software alternative to the QWERTY keyboard. It is mostly used by individuals with disabilities or otherwise restricted mobility and dexterity in their hands and fingers, as well as on mobile devices where keyboards are smaller and less efficient (though mobile devices are not the focus of this paper). Although human speech is much faster than typing speed for most people, speech-to-text simply does not offer the same functionality that a traditional keyboard offers. The remaining alternatives primarily consist of alternative layouts for the keys of the keyboard, of which I have previously mentioned two. Using algorithmic analysis, a keyboard layout was proposed which would minimize the distance fingers need to travel when typing texts, thus improving efficiency and limiting discomfort. This layout claims to provide a 6.04% improvement in distance traveled as compared to QWERTY when tested on a range of texts from different subjects. Furthermore, the authors argue that the algorithm can be applied to keyboards of other languages besides English, which are not catered to by layouts such as QWERTY and Dvorak (Onsordi & Korhan, 2020, p. 1-10).

Alternatives to the mouse are slightly more prevalent than those of the keyboard, although they are still not nearly as popular as the mouse. The main alternative often comes on laptop computers in the form of the trackpad. The trackpad offers a flat surface for users to slide their finger on, as well as pressable areas or buttons on the lower portion. The finger controls the movement of the cursor on the screen in the form of a sliding or dragging motion, while the pressable areas or buttons correspond to the left and right mouse buttons. In order to scroll, two fingers must be placed on the trackpad at once and slid upwards or downwards. Other alternatives that have been somewhat fazed out by the trackpad and mouse are the trackball and pointing stick. The trackball consists of a ball (about the size of a ping pong ball) housed within a hardware mold that sits flat on a surface. The user rotates the ball to simulate the movement of the cursor, with buttons on the side to represent the left and right click options. The pointing stick is a small textured rubber circle that sits in the middle of the keyboard, between the G, H, and B keys. It is usually concave or convex to allow the user to more easily control the movements. The pointing stick allows the user to slightly push the rubber in a two dimensional plane in order to move the cursor. There are usually buttons at the bottom of the keyboard, below the spacebar, to reflect left and right click.

Newer alternatives to the mouse include the touchscreen and eye tracking. While the touchscreen gained popularity in smartphones and tablets, it has begun to make its way into laptops and even desktop computers. The touchscreen allows the user to select items in the GUI by touching them with their finger. The touchscreen still remains fairly uncommon in laptop and desktop computers, and options that include them tend to be slightly more expensive than their non-touchscreen counterparts. Eye tracking, on the other hand, seems to be rising in popularity. Eye tracking for computer use originally became prevalent for those who had limited to no mobility in their hands or arms and required an alternative to other hardware options that control the cursor. Researchers Muhammed Tas and Hasan Yavuz developed an eye, eyebrow, and head tracking system at Eskisehir Osmangazi University in Turkey. The system, named Difference Between Eye and Eyebrow (DEEB), was designed for disabled individuals such as people with MS, ALS, and stroke victims. The system used the eyes to move the cursor and different actions to simulate other inputs, such as left and right eye blinks for left and right click; upward, downward, left, and right head movements for various shortcut or functionality items like typing characters, activating speech-to-text, scrolling, screenshots, etc.; and eyebrow lifting to exit the current mode. The results of their testing showed that the DEEB was able to detect all movements with perfect accuracy under controlled conditions, and that users in the experiment were able to complete tasks in a similar (slightly slower) duration as compared to using a mouse (2022, p. 632-640). Eye tracking has currently begun to gain widespread commercial appeal in virtual and augmented reality headsets. These headsets are either connected to a computer or contain their own processing ability within the headset, and they are usually paired with some other sort of controller or gesture based commands.

User Experience

A number of studies have been conducted in order to examine the adverse effects of using a mouse and keyboard over extended periods of time. David Rempel and colleagues sought to understand how hand and arm pain from keyboard use may be influenced by the type of key switches that the keyboard has. They performed a study by randomly assigning users with carpal tunnel syndrome to different keyboards which functionally differed only in keyswitch design. Carpal tunnel syndrome is a disorder often associated with computer use which causes tingling, numbness, and pain in the hand and wrist area. Keyboard A, the Protouch keyboard from Key Tronic, had linear key switches with a spring, while keyboard B, the MacPro Plus keyboard, had 2-ounce rubber domes. The study showed that after 12 weeks the participants who used keyboard A reported reduced hand pain as opposed to those who used keyboard B. The researchers also found that users of keyboard A performed better on a timed test after the same 12 week duration, which led them to conclude that keyboard A positively impacted the test subjects as opposed to keyboard B (Rempel et al., 1999, p. 111-118).

Chris Jensen and peers conducted a study on muscle activity and musculoskeletal symptoms when performing prolonged work with a computer mouse. The study includes a questionnaire survey and a workplace study, both regarding computer-aided design (CAD) professionals. The survey found that negative musculoskeletal symptoms were much more common in the mouse-using hand, and that these symptoms were more prevalent in women as opposed to men. The survey made sure to account for dominant vs nondominant hand in any symptom differences by including a range of individuals that varied in which hand they used the mouse. The workplace study found that the mouse operating hand and limb had many more repetitive movements, and the upper arm and wrist positioning was much more static in the mouse operating hand than the other. The study concludes that the repetitive nature of mouse usage and lack of other movement contribute to a risk for negative musculoskeletal symptoms (Jensen et al., 1998, p. 418-423).

A third study, performed by Anker Jorgensen and colleagues, sought to pit the computer mouse and keyboard against each other for the same task. The research study was designed to put users under pressure through time constraints and make them use both input devices (one at a time) to make fast selections of prompted colors. According to the study, the participants responded faster and made more correct selections with the keyboard, yet they also had significantly more incorrect responses. In terms of the experiences of the users, the study found that a large majority liked using the keyboard more, primarily due to the fact that those users could standardize the process and develop a strategy. The keyboard was also preferred due to comfort and the fact that the mouse was more prone to causing visual strain and frustration (Jorgensen et al. 2002, p. 317-319).

In addition to examining the existing literature regarding the experience of users of the mouse and keyboard, I also designed my own survey to gather data on the user experience for these artifacts. A survey was created and distributed through the use of Google Forms. I distributed the survey to various age ranges and professional backgrounds, with most of the respondents being under 25 years of age. The questions in the survey can be found below in Table 1.

Table 1: Survey Questions

How often do you use a computer keyboard?	How often do you experience pain or discomfort when typing for an extended duration on your computer?
Would you be willing to spend 50-60 hours learning a new keyboard layout if it meant your typing speeds would be about 6% faster and your fingers would travel 6% less distance (resulting in potentially less pain and discomfort)?	Have you ever used an alternative keyboard layout or design than the regular QWERTY keyboard? Or an alternative to the mouse? If so, what was it and how did you like it?
How often do you use a mouse with your desktop/laptop computer?	How often do you experience pain or discomfort when using a mouse?
Which do you prefer when using a computer? (Mouse, Trackpad, Trackball, Touch screen, Other)	Do you tend to enjoy the experience of using a mouse or keyboard more?
Are there any changes you would make to the mouse or keyboard? If so, what?	Are there any alternatives to the mouse and/or keyboard you have seen that excite you? If so, what?

I had a total of 60 respondents to the survey. The vast majority of respondents (83.3%) said they use a computer keyboard “almost every day”. When it came to pain and discomfort, only 26.7% of respondents reported never experiencing pain or discomfort when typing, and 58.3% said they experienced it occasionally. When asked if they would invest time to learn a slightly different and more efficient keyboard layout, only 21.7% responded yes with the remaining portion split fairly evenly between no and maybe. Almost none of the respondents had tried any alternative keyboard layouts or designs. When asked how often participants used a mouse with their desktop/laptop computer, just over 80 percent of the responses were split evenly between “almost every day” and “never”, with the remaining little less than 20 percent using a computer mouse intermittently. Regarding pain or discomfort when using a mouse, 70% reported never experiencing pain, and the next largest percentage was "occasionally" at 26.7%. The majority of participants preferred the mouse over other alternatives at 61.7%, while the trackpad was the next closest at 25%. When survey takers were asked if they enjoyed the experience of using a mouse or keyboard more, about half (51.7%) responded that they preferred the keyboard, 25% preferred the mouse, and 23.3% had no preference. When asked about potential changes to the mouse or keyboard, there were not really any common themes fundamental to the designs. Many preferences were related to aspects that can vary across designs of each device and already exist, such as size, support elements, and touch features. When asked about any possible alternatives that excited the respondents, the common preferences were things like eye tracking and the technologies offered by the Apple Vision Pro and Neuralink.

Analysis

Throughout my research, the overarching framework that best explains the interaction between the keyboard and mouse and users in society is the Social Construction of Technology (SCOT) framework. The history of the keyboard and mouse highlight many examples of how humans interacted with these technologies in order to shape them to varying needs of the time in terms of social, economic, and technological concepts. The adaptation of the typewriter into the computer keyboard shows how people at the time were able to take existing technology at the time and apply it to a new concept that they were introduced to. The invention of alternative keyboard layouts displays interpretive flexibility of the original design and how it can be manipulated for certain needs. Additionally, the computer keyboard became much more prominent and useful when it was able to be paired with the video display terminal instead of its previous uses with solely text based systems and punch cards. The evolution of different types of keyboard switches displays a careful balancing act between innovation, performance, and market competitiveness. This is also extremely relevant regarding the mouse. As I discussed earlier, the original idea for the mouse came from a design to measure two dimensional surfaces and was adapted to the computer application. The original mouse design being paired with the chordset demonstrates how it was developed for the purpose of text-based computer systems before being adapted to the invention of the GUI. Additionally, in order to be able to mass market and commercialize the product alongside the rise of Apple's computers, they spent a large amount of time and effort redesigning it to reduce the cost and improve reliability. They were able to shape the technology to the current needs and desires of their situation. Throughout the development of these devices, they were molded and shaped alongside the changing landscape of how humans interact with computers. I believe that the reason they have not changed much over the past two to three decades is due to the fact that the way in which we have interacted with computers has also largely stayed the same over that same period of time, so less adaptation has been needed.

Another aspect of the Social Construction of Technology framework that pertains to the mouse is discussed by Paul Atkinson. He points out how, historically speaking, typing was thought of as a feminine activity through the 1980s. Atkinson provides multiple examples and anecdotes of how males were seldom, if ever, displayed typing properly on a computer in advertisements and other media channels. The addition of the mouse to the setup allowed the use of the computer to be perceived in a different way than it had before as just an advanced typewriter. This was more attractive and provided a different aesthetic for male managers and other men that interacted with computers in the office (2007, p. 57-60). This also relates to Langdon Winner's article *Do Artifacts Have Politics?*, when he argues that the politics of a technical artifact depends on the social and economic systems in which they are embedded (1980, p. 122). Due to the fact that the computer was embedded in the office environment, and the way it was primarily used by female secretaries or other note takers, it was able to be interpreted this way. The mouse was able to change the computer's role in the social and economic system it was embedded in, which is one of the reasons why it became so popular.

While the mouse and keyboard have become widely adopted and permeate our culture, there are still a number of reasons why they could have been replaced over this time. There are a number of alternative computer input devices that can perform the same functions that they do, and these alternatives may even perform specific functions better than the keyboard and mouse. I believe that their versatility, reliability, widespread compatibility, and prominence in today's culture are the guiding reasons why they remain a mainstay. While there are multiple alternative keyboard layouts they may provide slightly increased performance, they are not evidently superior enough to get users to switch from the traditional QWERTY layout that they first learn. This is supported by my survey results, where only 21.7% of respondents said that they would take the time and effort to learn a new layout. When it comes to the computer mouse, the only alternative I have discovered that can perform the same tasks with relatively similar performance is sophisticated eye tracking systems. However, when taking into account the whole package including price, accessibility, and the ease of use of the buttons and scroll wheel, I still believe that the mouse is the superior package at this time.

The one thing I was surprised with over the course of my research was the general preference of the keyboard over the mouse. This was reinforced by both the study done by Anker Jorgensen and peers regarding the use of both under time pressure, as well as my surveying results. This did not make sense to me, as not only does the keyboard cause more discomfort and pain than the mouse, but I also believe that the mouse is more highly adapted and efficient for its purpose than the keyboard. It would be interesting to see more studies that dug deeper into this preference, and in what situations (if ever) the preference is flipped. I also wonder if this is the same across all cultures.

Discussion

The findings of this research shed light on the complex interaction between technology, user experience, and society. Understanding how these concepts evolved and were interwoven in one specific area of technology can allow us to better understand how other technologies, current or future, may do the same. Additionally, identifying the usability and ergonomics aspects of these two devices can help us improve human computer interaction and mitigate potential health risks that technology may cause. Our society will only become more dependent on technology as it advances and permeates its way further into our lives, so a nuanced understanding is important to consider as we allow this to happen.

I believe that future development of the mouse and keyboard should expand upon the existing research regarding ergonomic design principles and potential health impacts. Issues such as musculoskeletal disorders, carpal tunnel, and other pain and discomfort should not be ignored. As we use these items more in our daily lives, these impacts will only be exacerbated. This could involve incorporating adjustable features, promoting alternative layouts, and providing education on proper techniques. Additionally, further research and development should be done regarding advancements into computer input devices that are accessible to those with impairments or other specialized needs. These people deserve to have the same ability to interact with computers as any other user, regardless of their physical or cognitive abilities. By focusing on accessibility features, such as alternative input methods, adaptive technologies, and assistive devices, we can promote inclusivity and empower individuals with impairments to fully participate in the digital world.

Based on my research I do not believe that the mouse and keyboard will remain largely unchanged over the next 2-3 decades as they have during the past few. With the enhanced augmentation between computers and technology brought by devices such as virtual and augmented reality wearables, as well as the Neuralink implant which has already allowed its first patient to control a computer cursor using his mind, we may yet be in for another radical change in the human computer interaction space.

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