Learning and Designing Assistive Technology Devices for Upper-Body Motor Impairment Individuals

by

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Abstract

Many people use laptops and/or desktops for various everyday tasks and activities. However, people with upper-body motor impairments often face challenges due to limitations with their assistive technology devices, such as adaptive mice, specialized keyboards, and more. Additionally, knowledge gaps exist regarding assistive technology devices, difficulties with current tools (i.e., limited customization, accessibility, lack of standardization, etc.), and suggestions for improving tools specifically for laptops and desktops. For my capstone project, I explored ways to improve existing tools or develop new ones for these users. First, I captured responses using a Qualtrics survey. Then, I conducted remote semi-structured interviews to gain a deeper understanding of participants' assistive technology devices. Before the interviews, I asked participants to share video clips and images of their setups. In this study, I provided insights, design and development guidance, and suggestions that complement existing research on assistive technology devices for people with upper-body motor impairments. Some key recommendations include customization options to accommodate diverse needs and implementing continuous testing and monitoring to enhance future assistive technology devices for laptop and desktop use.

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1. Introduction and Background

People with upper-body motor impairments rely on various assistive technology devices when using laptops and/or desktops, such as speech-to-text software or a rollerball mouse. Upper-body motor impairments can affect various parts of the upper extremities, such as the arms, hands, fingers, or a combination, impacting a person's ability to use devices with tools like a mouse or keyboard. Previous studies have explored customizable and personalized wearables [1, 11], assistive robotics [14], and virtual reality hand function rehabilitation [8]. However, there is a gap in knowledge regarding which assistive technology devices people use, challenges they face with current tools, and potential improvements for laptop and/or desktop accessibility.

People with upper-body motor impairments often struggle with click-and-drag actions, multiple key functions (i.e., shortcut keys), combination of key and mouse functions (i.e., clicking on hyperlinks), and more when using a laptop and desktop [13, 15]. These difficulties arise from muscle weakness, paralysis, or limited fine motor control. Additionally, many assistive technology devices lack customization options, ergonomic designs, or lack compatibility with other devices. Several assistive device alternatives exist for laptop and desktop, such as specialized mouse and keyboard input modalities. A study by Hwang et al. (2003) analyzed mouse movements through multi-directional point-and-click interaction tasks to improve input and interaction techniques [7]. Through this study, Hwang et al. were able to provide an improved understanding of the underlying cursor movement, in order to develop more accessible interfaces. For example, they found that verification times for users with impairments were 65% of the average time required by able-bodied users, in extreme cases sometimes would be equal to or exceed the overall task completion time for able-bodied users. By designing a perceptive user interface that detects user needs and intentions, developers and designers could enhance accessibility for people with upper-body motor impairments. By gaining a deeper understanding of the tools and challenges involved when using a laptop or desktop, we can identify key areas for improvement, such as customizable accessibility settings and better software compatibility with assistive technologies. Specific improvements could include enhancing speech-to-text accuracy and reducing input fatigue by designing lighter peripherals. These advancements will guide the design and development of more inclusive and user-friendly technology.

This capstone focused on learning and improving current assistive technology devices for people with upper-body motor impairments navigating websites on a laptop or desktop. Many assistive technologies face compatibility issues, customization limitations, and a lack of universal standards. Addressing these challenges requires collaboration among users, designers, and developers to create tools that ensure accessibility. To gather insights on this topic, I used a mixed methods approach: surveys and semi-structured interviews. My research provides further insight and guidance on how to design and develop assistive technology devices that improves access to laptops and desktops for upper-body motor impairment people.

To address the challenges faced by people with upper-body motor impairments, this study contributes to the broader body of knowledge in accessibility and human-computer interaction by documenting user experiences, identifying recuring challenges, and highlighting recommendations for improving assistive technology when using a laptop and/or desktop.

The research questions I am explored for my project are:

- RQ1. What barriers are there with current assistive technology devices for those with upper-body motor impairments when using a laptop and/or desktop?
- RQ2. What expectations do users have for assistive technology devices when using a laptop and/or desktop?
- RQ3. How can we enhance existing technology to offer improved accessibility for people with upper-body motor impairments when using laptops and/or desktops?

2. Related Work

2.1 Types of Input Used by People with Upper-body Motor Impairments

When people with upper-body motor impairments use laptops, desktops, and mobile devices, there are various types of inputs to perform tasks, navigate webpages, and more. The different types of inputs mentioned by Li et al. (2022) are touch, voice-based, eye-based, head-movement, face-based/mouth-based, and other inputs [9]. Preference for and utilization of inputs depends on the type of diagnosis of motor impairment. Results of this study show voice and touch are the most preferred input. Furthermore, multimodal input may provide opportunities to accommodate diverse user needs. Another study explored which input (mouse, touchpad, and touchscreen) was most effective for Malaysian people with motor impairments' browsing performance [6]. Results indicated that mouse input performed the fastest and had a faster average browsing time, compared to a touchpad and touchscreen. The choice of input modality often depends on the specific task being performed. Understanding which input methods are most helpful can provide insight usage patterns and user preferences. Based on this, I aimed to investigate the most commonly utilized physical assistive technologies for laptop and/or desktop use.

2.2 Exploring the Use of Mouse and Keyboard Inputs

With laptops and desktops being used daily, both mouse and keyboard input modalities serve as essential accessibility tools, facilitating navigation within computing environments. These modalities provide an alternative for people with upper-body motor impairments who face challenges using voice input. Andreas et al. (2022) developed a personalized mouse and keyboard to compare their functionality and performance with a standard mouse and QWERTY keyboard [2]. This study revealed that the personalized mouse achieved a throughput three times higher than a commercial mouse, while error rates on the alternative keyboard were comparable to those on a QWERTY keyboard. The personalized mouse operated through a spectacle frame containing inertial measurement unit and additional force sensitive resistors, which triggered mouse clicks using the masticatory muscle. Meanwhile, the alternative keyboard consisted of force sensitive resistors that functioned as customizable keys. Throughput, a metric measured in bits per second, accounts for task difficulty and the time required to click on targets. Having a higher throughput, allows a mouse to transmit movement data, button clicks, and other input signals more frequently and quickly to a computer, reducing input lag, and allows for better precision. Andreas et al. found that the alternative keyboard demonstrated a slower typing speed. They suggested that while the keyboard's general functionality showed promise, it required further improvement. Currently, the alternative keyboard demands a higher workload than the QWERTY and a commercial mouse. Future studies plan to test its effectiveness with both non-disabled participants and people from the target population.

Another study explored a co-design approach involving 26 designers and three motor-impaired designers to create a new keyboard and mouse while gaining insight into the lived experiences of people with physical disabilities in relation to human interface devices [4]. Cossovich et al. (2023) designed a workshop to facilitate collaboration and creative problem-solving in groups led by three facilitators. Initially, participants with motor impairments found it intimidating to work alongside with non-disabled designers. However, as they shared opinions and developed solutions together, they grew more comfortable, benefiting the support from the team. Cossovich et al. identified the need for a Jacdac wired sensor, an open-source hardware and software platform for microcontrollers and peripherals, to enhance accessibility and reduce complexity. This sensor advocated for a more transparent process for input and output, emphasizing that Jacdac's larger size made it more accessible compared to industrial sensors with complex connections unfamiliar with participants. In this study, Jacdac was assigned three modules: push-button switch, a rotary encoder, and sliding potentiometer. These components allowed designers and participants to mockup solutions from their prototypes.

2.3 Touch Input

A lab study with 32 participants, 16 identifying having upper-body motor impairments and 16 without disabilities, compared touch and mouse input performance and examined differences in throughput input tasks [5]. Findlater et al. (2017) found that while touchscreen input had advantages over a mouse in terms of speed, the benefits in terms of lower error rates were only observed for users without motor impairments. Tapping interaction, a common technique used on touchscreen devices, played a pivotal role in this study. The findings highlight the need to enhance tapping accuracy, especially considering the various gestures (i.e., tapping vs. swiping) on touchscreen when compared to non-touch screen modalities, like a mouse and keyboard. Similarly, Mott and Wobbrock (2019) explored their touch model, Cluster Touch, on 12 participants – 4 with motor impairments and 8 without using various trials (i.e., standing for motor impaired vs. walking and standing for non-motor impaired) [12]. Their results showed that Cluster Touch was more accurate than other models and phone sensors. Additionally, both groups had relative touches near their intended targets. As touchscreen models continue to evolve, researchers can apply similar techniques to laptops and/or desktops. Developing the model can help provide another way for people with upper-body motor impairments to interact with a laptop and/or desktops.

3. Survey Method

Previous research has focused on assistive technologies themselves, but there is limited understanding of how people with upper-body motor impairments use these tools on a laptop and/or desktop. To address this gap, I conducted a survey and semi-structured interviews to explore various types of assistive technology devices used, user experiences, and challenges encountered. This section (Section 3) presents the survey method, while Section 4 details the survey results. The semi-structured interview method is outlined in Section 5, with findings discussed in Section 6.

3.1 Survey & Design

To gain broad insights into the diverse experiences and challenges of people with upper-body motor impairments, I conducted a survey to collect a large sample of data. This approach captured a wide range of responses regarding usage of assistive technology devices, limitations of current or previous devices, user suggestions for improvement, and more. I distributed the survey across various platforms, including Reddit channels (i.e., r/AssitiveTechnology, r/MultipleSclerosis, r/spinalcordinjuries, and more), multiple United Spinal Associations, various Spinal Cord Injury Associations, and United Cerebral Palsy Associations. To participate, respondents needed to have an upper-body motor impairment and regularly use a laptop and/or desktop. The survey covered several topics, including demographic information (i.e., type of upper body motor impairment, length of impairment, impact on daily life), type of assistive technology device(s) used, accessibility ratings, issues encountered with assistive technology devices, and suggestions for improvement. I collected survey data using Qualtrics from March 2024 to June 2024. Before proceeding with the questions, respondents reviewed a consent form detailing the study's purpose and procedures. The form specified that respondents must have an upper-body motor impairment. Those who agreed proceeded with the survey, while those who declined were redirected out of the survey.

The survey contained fifteen questions, though some were shown conditionally based on their responses to whether respondents use assistive technology on a computer (Question 4) and their current assistive technology device (Question 5). Questions included short answer, Likert scale, multiple choice, and more. Respondents were not compensated for their participation in this part of the study.

3.2 Respondents

Commented [KS1]: You call them respondents in your description, I would do that here, too.

Commented [MR2R1]: Fixed: changed wording

Thirty-nine responses were collected; however, one respondent skipped over the question regarding their type of upper-body motor impairment. Based on the recoded responses, I categorized participants into six groups: cerebral palsy, congenital condition, spinal cord injuries (SCI), impairments and weakness, and muscular dystrophy; see Table 1. Four respondents indicated having cerebral palsy, whether it was mild cerebral palsy or spasticity/dystonia in the upper limbs. One respondent indicated being a congenial amputee, as they were missing their right arm, two fingers on their left hand, and their left arm being unable to bend. Three respondents indicated having brachial plexus injury, as they indicated having complete brachial plexus where their left arm is paralyzed or brachial plexus paralysis and problems with their right arm deltoid, originally in column Q6. Meanwhile, seventeen respondents indicated having SCI, whether C3 incomplete, C3/4 quadriplegic, C5 quadriplegic, C6 incomplete, or T6 paraplegic. Twelve other respondents stated having any impairments or weaknesses, which included left-side hemiparesis, finger paralysis, weakness in their core, weakness in arms and hands, or minimal movement in their arms. Lastly, one participant indicated having muscular dystrophy.

Category	Type of Upper-body Motor Impairment
Cerebral Palsy	• (2) Cerebral Palsy • (1) Mild Cerebral Palsy • (1) Spasticity/ dystonia in upper limbs
Congenital Condition	• (1) Congenital amputee: missing my right arm and two fingers on my left hand, left arm doesn't bend
Brachial Plexus Injury	• (1) Complete Brachial Plexus Injury - left arm paralyzed • (1) Brachial plexus injury • (1) Brachial plexus paralysis and right arm deltoid: originally in column Q6
Spinal Cord Injuries (SCI)	• (1) Incomplete C3 SCI: Partial use of left arm/hand; no use of right arm/hand • (1) C3/4 • (1) C4 incomplete spinal cord injury • (1) C4/5 Incomplete quadriplegic; regained limited mobility with hands and arms • (6) C5 quadriplegic (complete & incomplete) • (1) C5/6 SCI level and my hands and arms were affected. • (1) Incomplete C5/6 quadriplegic • (1) C6 incomplete spinal cord injury • (2) SCI

	• (1) T6 Paraplegics • (1) Quadriplegic
Impairments & Weakness	• (1) Impairment in left arm and shoulder, and right arm, shoulder and hand (from spinal cord stroke) • (1) Left side hemiparesis (from SCI) • (1) No major left and minimal right arm movement • (1) Right hand and arm weakness • (1) Hand and arm weakness • (1) Weakness in the arms, hands, and fingers (back muscles are weak & have scoliosis) • (1) Left arm/hand motor skills from spinal cord injury • (1) Finger paralysis • (1) Weak arm and fingers • (1) Weakness in hands • (1) No hands • (1) Weakness in core
Muscular Dystrophy	• (1) Muscular Dystrophy

Table 1. List of Upper-body Motor Impairments gathered from survey responses. Number in () indicates the frequency of responses.

3.3 Survey Analysis

After collecting survey responses, I conducted a thematic analysis to examine respondents' experiences and challenges with upper-body motor impairments. First, I removed blank or partially incomplete responses to ensure the dataset was reliable and accurately depicts the respondents' experiences. Since Qualtrics automatically submits responses when respondents abandon the survey after one week, this resulted in a number of incomplete entries. Out of 80 survey respondents recorded, only 39 were fully completed. Next, I categorized responses based on different types of upper-body motor impairments; see Table 1.

Commented [KS3]: How does cleaning ensure that it is reflective of their experiences?

Commented [MR4R3]: Fixed: changed wording

For each survey question, I identified recurring patterns and unique perspectives by generating themes based on respondent feedback. I initially coded the data into specific categories, which I then grouped into broader overarching themes. Afterward, I refined these themes to enhance clarity, consistency, and alignment. Some respondents' responses fit into multiple codes, as they described various aspects of their device or experience. For instance, in response to one question about the impact of their impairment, themes such as "difficulty with specific tasks", "loss of independence", "body parts affected" arose from respondents' answers. This thematic categorization provided a structured understanding of respondents experiences, highlighting common challenges and suggestions for improving assistive technologies. By using this method, I ensured all insighted were thoroughly analyzed, offering a comprehensive view of user needs and opportunities for innovation.

4. Survey Results

4.1 Impact and Living with an Upper-body Motor Impairment

To understand the duration of participants' experience with upper-body motor impairments, respondents were asked how long they had been living with their condition. The response options were: < 6 months (0, 0%), 6 months to 1 year (1, 2.6%), 1 to 3 years (2, 5.3%), 3 to 5 years (1, 2.6%), and > 5 years (34, 89.5%). Only 38 respondents answered this question, as one respondent (1, 2.6%) skipped it since it was not required. These responses provided insight into the long-term experiences of people with upper-body motor impairments, with the majority having lived with their condition for over five years.

To further explore how their impairments impacted their daily lives, participants answered open-ended questions. Their responses were categorized into six themes: difficulty with specific tasks, loss of independence, body parts affected, use of adaptive equipment, increased time and effort, and breathing and balance issues.

Nine respondents (23.1%) noted difficulties with specific tasks, explaining that daily activities had become challenging or that using a laptop/desktop caused fatigue. S25 stated, "It is difficult for me to grab and hold things as well as type use mouse or play video games," highlighting how their impairment affects their experience on a laptop/desktop.

Loss of independence was another key theme. Eight respondents (20.5%) reported relying on caregivers or assistance for daily tasks. Respondents mentioned being unable to use specific body parts (i.e., left arm, hands, finger function, and more) or experiencing limited fine motor skills and fatigue after performing certain tasks. Two respondents (S5, S27) specifically stated they utilize caregivers, i.e., hired assistants, for Activities of Daily Living (ADLs). Others (S16, S23, S34) noted they depended on family members for assistance. Their responses highlighted the varying levels of support needed for everyday tasks.

The use of adaptive equipment also arose as a theme. One respondent (2.6%) mentioned having partial use of their arms and being unable to complete tasks independently, requiring adaptive equipment for essential tasks, such as eating (S26). They simply stated, "[…] I am unable to pick up anything independently. I am reliant on adaptive equipment to be able to eat." In addition, S26 mentioned experiencing balance issues and very shallow breathing due to diaphragm and abdominal muscles limitations.

“Also, due to my diaphragm and lack of abdominal muscles I have very shallow breathing,” mentioned S26. This highlights the broader physiological effects of upper-body motor impairments beyond mobility, demonstrating their impact on essential bodily functions as well.

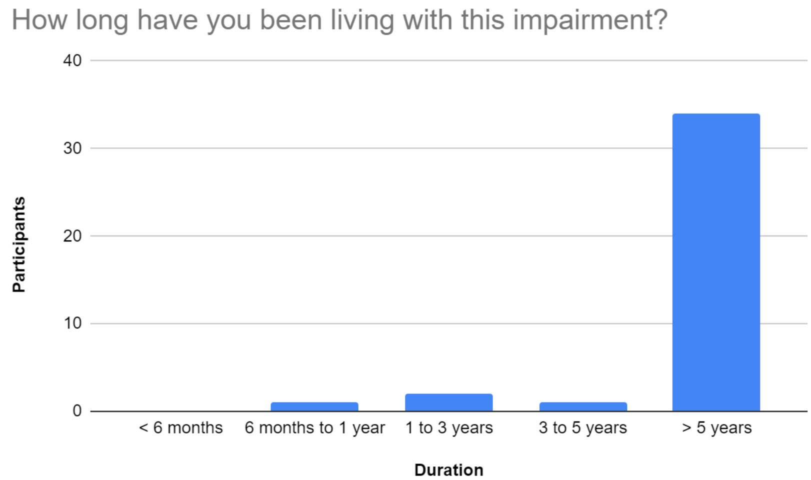

Figure 1. Chart of number of respondents’ length of living with an upper-body motor impairment from the survey responses, based on pre-selected categories.

4.2 Assistive Technology Devices

I asked respondents about their usage of assistive technology devices. Twenty-seven (69.2%) respondents reported using at least one assistive technology device, while twelve (30.8%) responded they did not. Those who used an assistive technology devices specified which devices they currently use, resulting 47 different devices recorded. Seventeen (43.6%) respondents mentioned using a mouse, 11 (28.2%) used keyboards, two (5.1%) used prosthetics and/or orthotics, and 18 (46.2%) used other assistive technology devices; see Figure 2. Although assistive robots were listed as an option, no respondents indicated using one. Mouse devices reported from respondents included a rollerball mouse, mouse with a Velcro attachment, a lightweight mouse (54g), and a head mouse. Respondents who used keyboards mentioned an on-screen keyboard, a keyboard with tactile bump dots, an adaptive keyboard, and a smaller keyboard. Devices categorized under ‘Other’ were broken down as voice recognition and dictation software (i.e., voice-to-text, Dragon, voice assistance), physical adaptions and aids (i.e., Velcro mouse, QuadJoy, head mouse), smart assistants (i.e., Amazon Alexa), and screen and visual aids (i.e., screen reader and screen magnifier); see Table 2.

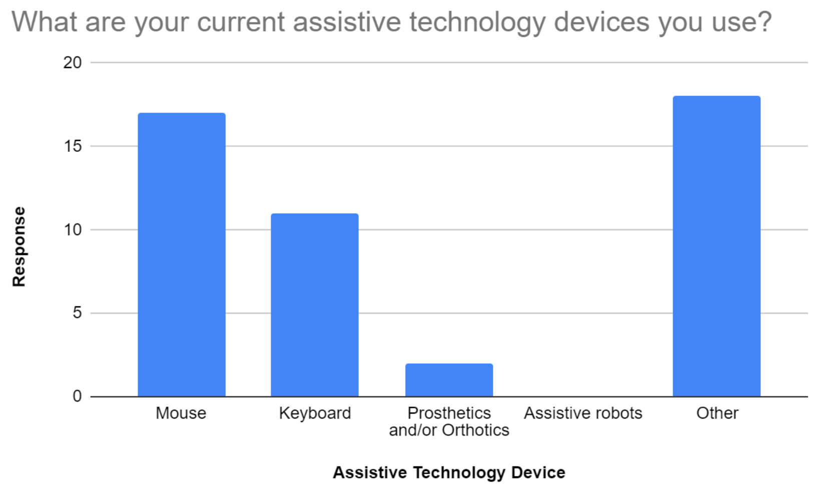

Figure 2. Chart of current respondent's assistive technology device(s) from survey responses, based on pre-selected categories.

Category	Assistive Technology Device
Voice Recognition & Dictation Software	• (3) Voice to text / talk to dictate • (3) Voice / speech recognition software / Dragon NaturallySpeaking • (2) Voice dictation • (1) Voice assistance
Physical Adaptations & Aids	• (1) Velcro mouse to hand • (1) Universal hand splint • (1) Typing aids • (1) QuadJoy • (1) Head mouse • (1) Head tracking software
Smart Assistance	• (1) Amazon Alexa

Screen & Visual Aid	• (1) Screen Reader • (1) Screen Magnifier

Table 2. List of other current assistive technology devices from survey responses from Q5 in the "Other" category. Number in () indicates the frequency of responses.

Those who previously used assistive technology devices were asked about any assistive technology devices. Eighteen (46.2%) participants indicated using any previous assistive technology devices, while 21 (53.9%) responded that they had no previous device. Some previous assistive technology devices included Dragon software/dictation, speech recognition (speech to text, Microsoft Voice), adaptive keyboard, keyboard with tactile bump dots, rollerball mouse, TrackIR, prosthetics, TENS electronic stimulation, and Speechify. Respondents used either one or multiple previous assistive technology devices.

Afterward, respondents were also asked why they stopped using their previous assistive technology devices. Responses were categorized into recovery/improvement in condition, technical issues, usability and effectiveness, changed circumstances, and preference for alternative devices. Respondents who mentioned recovery/improvement stated that their hand fully recovered or had recently improved. Two participants (S2, S10) both previously used dictation software, but no longer use it as their hand has recovered. Concerning technical issues several respondents cited reliability and durability concerns for no longer using their assistive technology device. S4 for example, wrote, "Too heavy and awkward, Bluetooth unreliable." Their adaptive keyboard's Bluetooth became unreliable, due to connection issues with their laptop/desktop, leading them to use other assistive technology devices. S20 previously mentioned using a rollerball mouse; however, the device became worn out and they were unable to find a suitable replacement.

Meanwhile, for usability and effectiveness, respondents expressed frustration with the accuracy and efficiency of certain software-based assistive technologies. S26 mentioned the inconsistency and numerous mistakes of using voice assistance software, therefore spending more time to correct mistakes than accomplishing tasks. Meanwhile, S21 mentioned previously using Dragon software and Speechify, but noted navigating through it became hard due to weakness in their hands. These challenges highlight the need for more reliable and efficient assistive technologies that can better support users in performing tasks with minimal frustration.

Some respondents indicated changes in their environment or physical condition, making their previous device unusable. S30 mentioned having a noisy environment, which made it difficult to use their voice software application. This made it difficult for the software to recognize words, leading to spending more time correcting their work. S23 became unable to use their keyboard with tactile bump dots, "I am now bedridden and cannot use a keyboard. Additionally, my typing speed is very slow." Lastly, for preference for alternative devices, S32 mentioned they still use their writing device, but have found other assistive technological devices (i.e., mouse, keyboard, and voice dictation applications) that helped suit their needs. In addition, S24 previously tested various assistive technology devices to suit their needs, which led to using TrackIR. After exploring a bit more, they ended up switching to QuadJoy, which was better and was worth the investment.

Additionally, respondents were asked to rate the accessibility of their devices. Only thirty-eight participants selected from five ratings to select from: Very Inaccessible (2, 5.3%), Inaccessible (1, 2.6%), Neutral (13, 34.2%), Accessible (17, 44.7%), and Very Accessible (5, 13.2%); see Figure 3. A fair number of participants were somewhat satisfied with their assistive technology device. These participants are currently using a mouse (i.e., rollerball), keyboard, and speech recognition.

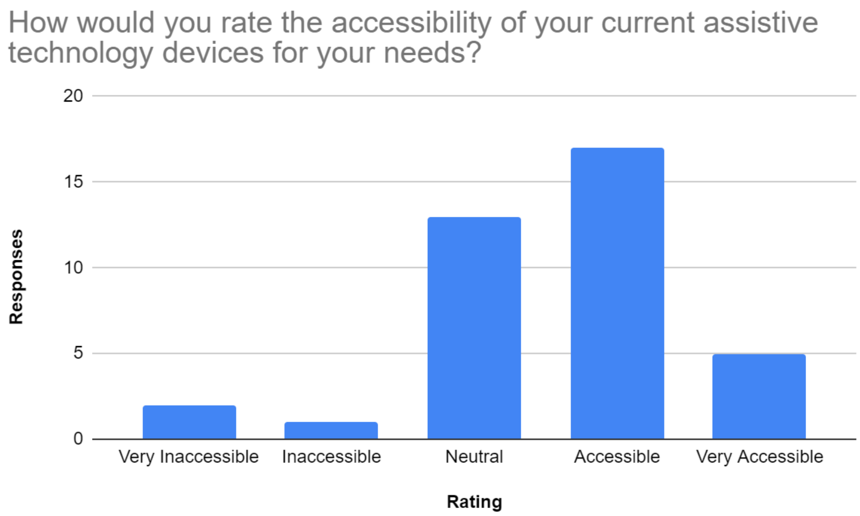

Figure 3. Ratings of survey participants' accessibility of current assistive technology devices.

4.3 Technology Types & Issues/Improvements

4.3.1 Technology Types

Technologies for Speech and Voice. Survey data revealed several issues related to the accuracy and reliability of voice recognition. Background noise often interfered with software recognition, leading to inconsistent word interpretation and the need to repeat commands. Respondents S3, S5, S27 specifically encountered accuracy issues when voice software. These findings suggest that environmental factors significantly impact the effectiveness of voice recognition for users with upper-body motor impairments.

Weight and Ergonomics. One respondent mentioned relying on lighter devices due to hand weakness or experiencing poor ergonomics when using a single mouse with both hands. This highlights the importance of lightweight and compact devices. S13 wrote, "I use a very light mouse (54g) and I try to use a smaller keyboard for smaller distance between keys. So, weight + size of devices is very important." This insight underscores the need for assistive technology devices that can minimize the strain during prolonged use.

Assistive Technology Usability. Respondents provided numerous suggestions for improving the quality and usability of assistive technology devices, focusing on accessibility features and testing, device design and functionality, voice recognition and hardware quality, integration across devices, and general improvements. Regarding device design and functionality, some participants (S10, S13, S20) suggested innovations such as mice that can be operated using the palm for clicking, two-handed mice to distribute tasks across both hands, and finger contraction sensors for customizable clicking actions. For instance, a mouse could incorporate touch-sensitive and pressure-sensitive functionality, where applying more pressure triggers a right-click, and double taps initiate a click-and-drag action. For accessibility features and testing, respondents (S3, S5, S8) highlighted the need for features similar to Apple's AssistiveTouch and head tracking, extensive testing with users who have upper-body motor impairments, and increased awareness through organizations and support groups. Expanding these ideas could offer both ergonomic and functional benefits, particularly for users with significant limitations/physical restrictions.

Alternative Input Methods. Enhancing input methods also surfaced as a priority. Respondents (S12, S20, S30) recommended larger keyboard keys, two-handed mice, and more accessible keyboard shortcuts (e.g., copy-pasting). Voice recognition and hardware quality were identified as areas needing improvement, with calls for built-in speech-to-text systems, higher-quality voice recognition software to reduce errors, and more affordable devices with similar high-quality material. Currently, users often need to correct errors/mistakes when using voice recognition, especially in noisy environments where the system struggles to capture input accurately.

These insights provide valuable guidance for the future development of assistive technology. By addressing these challenges and incorporating user-suggested improvements, designers and developers can create more accessible, functional, and user-centered technologies.

4.3.2 Issues and Improvements

Physical Discomfort and Fatigue. S1 and S15 described experiencing fatigue when using a laptop/desktop for extended periods. Specifically, S15 noted that the horizontal mouse movements were particularly difficult and caused fatigue more quickly. This highlights the physical strain of prolonged computer use, particularly when standard input devices do not accommodate users' needs. Implementing alternative input methods could help reduce strain and improve usability.

Environmental and Interaction Factors. Respondents (S23, S26) reported challenges with environmental and interaction factors, such as difficulty navigating their assistive technology on a small screen, struggling with small interactive elements on websites, or frequently reaching for standard keyboard keys. In particular, S23 who also has vision impairment, noted additional difficulty using a mouse to navigate websites due to limited screen visibility. The combination of poorly designed websites and limited assistive technology compatibility makes computer use challenging. To improve accessibility, designers and developers should incorporate larger interactive elements, mouse- and keyboard-friendly navigation, and ensure compliance with WCAG guidelines to accommodate diverse user needs.

Device Limitations. Some respondents (S26, S34, S35) highlighted specific device limitations, such as a lack of available assistive technology, software updates that render devices obsolete, or frequent system resets. S26 described the restrictions on the types of devices they could use. Whereas S34 and S35 commented on technical issues, with S34 stating, “Having to reset devices.” Lastly, participants (S19, S23, S24, S33, S37, S39) mentioned difficulties navigating overlays, assistive technology designed for a single diagnosis, or the time-consuming nature of typing. S39 wrote, “Occasional bugs in system, not recognizing what I'm saying, difficulty putting on hand/arm to use.” Without improvements in customization, efficiency, and system reliability, users may experience frustration, reduced productivity, and barriers to independent computer use.

General Improvements. Respondents suggested various improvements, including the development of wearable technologies to aid finger movement, accessible eye-tracking systems, and better instructional on existing assistive technologies. Respondents (S27, S29, S36) emphasized the need for refined voice-activated systems, voice commands that do not require programming expertise, and reduced AI-driven predictive text. While some of these technologies already exist - such Otter and Google’s voice software - many remain inaccessible or lack documentation for users to fully utilize them. Expanding accessibility and usability in these areas could enhance user experience and independence.

5. Interview Method

5.1 Semi-structured Interviews

Participants were recruited from those who opted for a follow-up interview, which I offered at the end of the survey after the initial 15 questions. In addition, to ensure participants met the study’s qualifications, I sent a pre-check email to verify their eligibility. To participate in a follow-up interview, respondents needed to have an upper-body motor impairment, use an assistive technology device, and regularly use a laptop and/or desktop. The email entailed three questions: “What type of upper-body motor impairment do you have?”, “Do you regularly use a laptop and/or desktop?”, and “Are there any assistive technology devices you use while navigating websites? If yes, please list the brand and/or model (if applicable).” I used questions 1 and 3 to cross-reference their survey responses for accuracy and authenticity. Meanwhile, question 2 ensured their participation aligned with the study's focus on laptop and desktop assistive technology devices. I sent this email was sent after they completed the survey and expressed interest in the interview session. For survey respondents who participated in the interview, I asked them to include images of their setup, send a 30-second to 1-minute video demonstrating how they use their assistive technology device on a laptop and/or desktop, and complete a consent form. Potential participants were asked to submit images that showed their whole setup and how they would typically interact with their assistive technology device(s). They were also asked to submit videos that showed them at their setup, accessing a website or program using their assistive technology device(s). The interview sessions took place over Zoom and were recorded through Zoom cloud, which provided both video and audio transcripts. Before each interview, I asked participants for verbal consent to be recorded, allowing them to modify or remove any statements they did not want included in the published version.

Interview questions focused on their experiences and interactions with assistive technology device(s). I scheduled each session for one hour, though the actual duration of sessions ranged from 25 and 56 minutes. In addition, participants received $15 as compensation for their time and expertise. Out of the 19 respondents who indicated interest, only nine followed through the interview.

5.2 Participants

Nine people with different types of upper-body motor impairments participated in the interview session. Each participant used their assistive technology device(s) on a laptop or desktop to interact with Amazon, the website selected for the study. During a quick live demo, I asked participants to perform specific tasks, including searching for a product, navigating though interactive elements such as dropdown filter, and scrolling through the page. Since Amazon was the most indicated response from survey respondents, I selected it as the website for the study. Table 3 presents information related to each participant.

Participant	Type of Upper-body Motor Impairment	Assistive Technology Device(s)
P1	Right arm and hand weakness	• Word dictation • Dragon dictation • iPhone dictation
P2	Impairment in left arm, shoulder, and right arm (shoulder and hand impairment due to spinal cord stroke).	• 2.4G Wireless Vertical Ergonomic Optical Mouse • (see Figure 4)

P3	No major left and minimal right arm movement	• Bluetooth mouse • Dragon software • (see Figure 5)
P4	Incomplete C-3 SCI: Partial use of left arm/hand; no use of right arm/hand	• Kensington Expert Mouse trackball • Plantronics Blackwire headset • Windows Magnifier • NV Access NVDA screen reader • Nuance Dragon Professional speech recognition • (see Figure 6 and 7)
P5	SCI	• QuadJoy • (see Figure 8)
P6	C5 incomplete quadriplegic	• Logitech M570 Gray Optical Trackball Wireless USB Mouse w/ receiver • On-screen keyboard • Voice software
P7	C5-6 spinal cord injury level (hands and arms were affected)	• Screen magnifier (Windows 11 native app and FastStone Capture software) • (see Figure 9)
P8	No hand dexterity and limited fine motor skills	• Typing aids • Keyboard shortcuts • Word prediction • Word Dictation • (see Figure 10)
P9	Quadriplegic	• Head tracking (Sesame

		enable) • (see Figure 11)

Table 3. Interview participant information.

5.3 Interview Analysis

I transcribed each participant's responses by reviewing the recorded Zoom session, then played once more to check for errors or missing information. In addition, I examined participant's submission videos and images showcasing their setups.

To analyze the data, I coded participants responses, assigning each code to a theme related to their interactions with assistive technology, such as "device challenges," "changes in lifestyle," and "trial and errors." I then grouped these codes into themes to highlight key patterns in the data. This categorization underscored the unique experiences of these participants. Through this analysis, I gained a comprehensive understanding of the barriers they encountered, their varied experiences, and ways to enhance assistive technology devices.

High Level Codes	Themes	Examples
Device Challenges	Difficulties with mouse and keyboards	• P6: "The mouse issue, it's such a pain having to click, click-back… trying to set that up so it doesn't do that…"
	Usability of Assistive Devices	• P5: "Talking and using [QuadJoy] at the same time is difficult… but I got used to it over time."
Change in Lifestyle	Adapting to their non-dominant hand	• P7: "I was right-handed and now I'm left-handed because of the disability… It took time to adjust."
Trial and Error	Finding suitable devices	• P2: "I tried out trackpads, trackballs, and different mice… I had to experiment to find the right fit."
Barriers of Products	Limited availability of suitable assistive technology devices	• P4: "There aren't many products that address both my motor and vision impairments."

	Cost of assistive technology devices	• P5: "I avoided getting this machine [QuadJoy] for years because it was expensive, but I decided it was worth it in the end."

Table 4. Examples of high-level codes, themes, and examples.

6. Interview Results

6.1 Learning about the Barriers

RQ1. What barriers are there with current assistive technology devices for those with upper-body motor impairments when using a laptop and/or desktop?

This study identified several barriers that people with upper-body motor impairments face when using technology. Based on participant responses, these barriers fall into four key challenges: changes in dominant hand usage, difficulties with mouse and/or keyboard, usability of specific devices, and the process of purchasing assistive technology devices.

Changes in dominant hand usage. One main challenge participants highlighted was the need to switch their dominant hand due to their impairment, which affected how they used a laptop and/or desktop. Five participants (P1, P2, P3, P4, P6, P7) indicated transitioning to their non-dominant hand. P6 shared, "I was right-handed before and now my left hand is the more dominant side. So yeah, I did have to kind of try to learn how to do everything with my left hand, which was very awkward, because that's not what I was used to doing." Similarly, P7 told us, "I was right-handed and now I'm left-handed because of the disability… The left hand/left arm is stronger than the right arm, so now I use my left arm/hand predominately more than anything now. [I] really don't use the right arm to do anything." All five participants explained that switching hands required time and practice to retain their newly predominant hand.

Difficulties with mouse and keyboard. Participants also described difficulties using a mouse and/or keyboard when navigating websites. Three participants (P2, P6, P8) shared their struggles with their devices. P2 stated, "Typing is quite difficult because I can only really use my left hand. So, I have to do everything one-handed apart from mouse stuff." Furthermore, P6 complained, "The mouse issue, it's such a pain having to click, click-back… trying to set that up so it doesn't do that… Windows 11 comes with a built-in voice software, and it doesn't always work, and it's not always accurate… So, I spend so much time erasing, and I get exhausted. With the roller mouse too, sometimes just doing that repetitive motion." In addition, P8 shared, "Anything where I have to click and drag is always more challenging. Like any document or website that I can't highlight the information and then copy and paste it." While some assistive technology devices provide shortcut keys to mitigate these difficulties, some participants still encountered accidental button clicks, causing them to lose progress on their work. This issue lead to frustration, as users had to manually disable certain functions to prevent errors.

Usability Challenges with Assistive Technology Devices. Some participants encountered usability issues of specific assistive technology devices. P5, for example, described difficulties using their QuadJoy device while speaking at the same time. They mentioned, "Talking and using it at the same time. But, on the other hand, also navigating… Because it's actually one click, and you can talk to it and find whatever. It's easier than typing, I guess." Although they found this issue minor, they eventually adapted as the device became part of their daily routine.

Purchasing Assistive Technology. Participants also faced challenges when purchasing assistive technology devices. Three participants (P4, P5, P7) talked about difficulties they encountered when purchasing their assistive technology device. Some reported limited product availability when they first acquired their upper-body motor impairment. P7 said, "In terms of the actual features, it was just only one item. So, there was no trying to compare this with other different products on the web page. They all had the same features within the same product." Meanwhile, P5 described initially avoiding the purchase of a QuadJoy due to its high cost but later decided it was worth the investment. They explained, "I avoided getting this machine [QuadJoy] for years because it was one of the pricier options, the other ones are cheaper. Ultimately, I decided that my levels of frustration warranted getting the most reliable, the easiest-to-use one. If you're going to use this thing [QuadJoy] every day of your life, it's going to be worth the money." Furthermore, P4 faced additional due to having both motor and vision impairments. They stated, "The biggest problem I have there is that Since I am tool diagnosis, I've got all of the issues that somebody with poor motor control has combined with all of the issues that someone who has very low vision has. There are not very many products that address both of those… It's not always easy to find products that fit my needs since I've got more difficulties than the typical customer." These responses highlight financial and accessibility challenges that affect a person's ability to acquire a suitable assistive technology device.

Overall, these findings illustrate the challenges that people with upper-body motor impairments face when using assistive technology devices. Learning and understanding these difficulties/barriers allows future researchers and designers to develop more accessible and user-friendly solutions that address these difficulties.

6.2 Learning about Expectations

RQ2. What expectations do users have for assistive technology devices when using a laptop and/or desktop?

This study identified five key user expectations for assistive technology: accessible guides, improved access to devices, affordability, developing interactive human devices, and overall user satisfaction.

Accessible Guides for Users' Needs. Many participants were unfamiliar with their device's full functionality or unaware of alternative assistive technologies. P1 expressed interest in more learning opportunities about devices, stating, "I would like a [more] remote learning kind of thing to get the ins and outs of it, then I might use it more often." This response suggests that a lack of educational resources prevents users from maximizing their devices' potential. Providing accessible guides might help users explore features tailored to their needs or discover other customizations could help users explore features tailored to their needs or discover customizations that improve navigation on laptops and desktops.

Access to Assistive Technology. Some participants (P1, P8, P9) reported limited exposure to assistive technology options. P1 commented, "I got the business one [Dragon dictation], [as] my brother got it for me. It was a present gift, so it was fairly expensive." Meanwhile, P9 similarly stated, "That [it] was all that was available." Additionally, P8 described challenges in finding a suitable typing aid, "I just need something that I could type with, and this [typing aid] is all that I've been able to find. I would rather have a stylist-end, but I haven't been able to find one of those... As far as I know, it didn't exist." These responses highlight a gap in availability, leading users to rely on familiar or easily accessible products rather than seeking better alternatives.

In contrast, P2 and P5 tested multiple devices before selecting their ones. P2 shared, "I tried out trackpads and trackballs, and different kinds of mouses… So, I tried some out, and this one was suitable for me because it holds my hand sideways, so it doesn't wear it out. And it means that only my good fingers are on the buttons, so I'm not accidentally pressing anything." When choosing their device, they visited an assistive technology department at a national rehabilitation center, where they tested various mice before making a choice. Furthermore, P5 explained, "Mostly trial and error. I mean as far as I can tell, this is the most reliable…" They also explained utilizing TrackIR and a head mouse before. These experiences suggest that hands-on testing opportunities can help users find devices that best suit their needs. Expanding access to assistive technology trials could improve users' ability to make informed decisions.

Affordability of Assistive Devices. Cost was another concern among participants. Many expressed a need for more budget-friendly options. A survey respondent noted that both cheap and expensive devices often use inadequate materials. P1 mentioned that their voice software was between \$115 - \$200, describing it as expensive. Additionally, P5 acknowledged, "I like this device. I would like it cheaper, but I can see how it's a specialty device. They're not mass producing it, so it's going to be pricey." Lastly, P9 honestly stated, "Make them cheaper." These responses indicate that while users recognize the specialized nature of assistive technology, high costs remain a barrier. Offering lower-cost options or financial assistance programs could improve access to these essential devices.

Human-Interactive Devices. P5 expressed interest in human-interactive devices, stating, "I think we're all waiting for that human interactive device where you think it and it happens. Weirdly, I've done some research into something similar to this, but it involves implanting microchips into your brain." Such technology could help people with upper-body motor impairments by reducing the effort needed for input and improving speed.

However, the development of human-interactive devices presents both opportunities and challenges, requiring careful consideration of ethical and technical factors.

User Satisfaction. To assess overall satisfaction, participants rated their assistive technology. Of the nine participants, five participants (P2, P5, P7, P8, P9) gave their devices the highest rating (5). P2 mentioned, "It just eliminates any difficulties I have with using a [standard] mouse. So, it's got some handy buttons I can use to make tasks easier and just fits nicely and helps me access my computer as normal." Using an ergonomic optical mouse allowed them to complete what tasks they have at hand, without complications. P5 said, "I'm quite happy with the device. I've tried a lot of different devices… I've used a head mouse, I've used a TrackIR." P7 discussed "I just have no problem doing it at all. That there is not [any] kind of hindrance or barriers at all, just go right to doing What I need to have done." Additionally, P8 mentioned, "It [the typing aid] doesn't slip off my hand or anything. So, it stays pretty good." These high ratings suggest that when users find a device that aligns with their needs, they experience a seamless and efficient interaction.

However, three participants (P1, P3, P6) rated their assistive technology device as a 4, citing minor but persistent usability issues. For example, P6 told us, "One thing that drives me crazy about my mouse is that there are these two buttons on the left-hand side. And if you accidentally click them, it will flop the page back to the previous one." To mitigate this issue, they manually adjusted the mouse settings to disable problematic buttons. However, one participant noted that their device's effectiveness depended on environmental conditions. P3 rated their dictation software as a 4 in quiet environments but as a 1 in noisy settings, stating, "As long as I'm in a quiet location, I'd say 4. If I'm in a noisy location, then it's 1… because it can't differentiate between my voice and other things that are being said." This response highlights the need for assistive technology that adapts to different environments.

On the other hand, P4 rated their assistive technology a 3, citing accessibility limitations. They described difficulties accessing information when text appeared as an image format rather than formatted text. In addition, some applications lack accessibility features, creating additional barriers. P4 explained, "There are many instances when I can't get the information I want. Typical difficulties are there is text that is in an image as opposed to being formatted as text by the HTML or the application is not accessible, accessibility enabled… The secondary difficulty is it's not always the case that my speech recognition engine can put in the information that I want to put in and sometimes just because of the way that they do it. For example, especially when you're typing a password, [it] won't let you cut and paste. They want to see individual keystrokes." These challenges illustrate how external software design choices can impact the usability of assistive technology, emphasizing the need for greater accessibility in digital interfaces.

By analyzing participants' ratings and feedback, this study identified both satisfaction with current assistive technology and areas for improvement. The data highlights the importance of access to device information, opportunities for hands-on testing, affordability, and advances in technology to address the varying challenges users face based on their specific upper-body motor impairment needs. Assistive technology is not a one-size-fits-all solution, participants emphasized the need for greater customizability in both hardware and software, allowing for tailored interactions that align with their unique conditions and usage preferences. These insights guide future development of assistive technology by addressing the need for accessible learning resources, cost-effective options, and customizable solutions. Many participants, such as P1, struggled to fully utilize their device due to a lack of education resources, which highlights the importance of accessible guides, remote learning opportunities, detailed tutorials. To address affordability, developers should prioritize budget-friendly materials and collaborate with function programs to reduce financial barriers, as P1 and P9 found assistive technology rather expensive. Additionally, customization played a crucial role, as P2 and P5 actively tested multiple devices to find the best assistive technology for their needs. To improve this process, manufacturers and rehabilitation centers should offer trial programs, allowing users to explore and refine their choices. By addressing these factors, assistive technology can become more user-friendly, affordable, and adaptable to individual preferences, ultimately improving access and usability for people with upper-body motor impairments.

6.3 Enhancing Assistive Technology Devices

RQ3. How can we enhance existing technology to offer improved accessibility for people with upper-body motor impairments when using laptops and/or desktops?

Three key ways to enhance existing technology on laptops and/or desktops include enhancing voice recognition, reducing reliance on AI-driven predictive texts, and incorporating more user testing. These recommendations stem from firsthand experiences with assistive technology, highlighting areas where improvements can make devices more effective and user-friendly.

Voice Recognition Software. Participants provided insights into potential improvements for assistive technology, particularly in mouse functionality, voice recognition software, and customizable options. P2 and P6 mentioned enhancing their current mouse devices by adding more programmable buttons or customizations to improve website navigation. P2 commented, “More buttons, more programmable buttons for shortcuts, I’d say could be quite helpful… Some extra features would be nice.” Similarly, P6 elaborated, “This [assistive technology device – trackball mouse] one’s a little cumbersome, the rollerball mouse and again [an] easier way to customize the buttons… Definetly improve the built-in software would be nice.” While both participants found their devices functional, their responses suggest that additional customization options could improve efficiency, as a mouse remains a primary navigation tool for many users.

Beyond mouse functionality, P3 spoke about improving speaking software by adding features to assist with ADLs. They discussed, “If there was a way that I could pause the speaking software by maybe holding a mouse in a certain spot for 10 seconds. If there was a button that I can do that and then do ‘whatever,’ and then hold it there again for it to come back on.” This idea emphasizes the need for intuitive, customizable controls

Commented [KS5]: Use of the word “more” implies a comparison. But without mentioning the comparison (more than what?) it’s kind of an empty statement and is no better than not having it: “we should make it more accessible” vs. “we should make it accessible” Unless you have a comparable element to your argument, and you include it in writing (no implications, please), it’s actually an incredibly poignant and powerful argument to leave the “more” out.

Commented [KS6R5]: I get that a lot of this use of “more” assumes “more than the status quo” but that’s still kind of a useless argument if we’re not going to lay out exactly what the status quo issue was.

that allow users to pause and resume speech recognition software without disrupting their workflow. Implementing user-friendly shortcuts through hardware controls could enhance usability and efficiency.

Reducing AI-driven predictive texts. Another key theme was reducing the reliance on AI-driven predictive texts for voice software. While predictive text can be helpful, it often introduces errors that require manual correction. Allowing users to toggle this functionality on and off could provide a practical solution. Many participants expressed frustration that their software misinterpreted words or phrases. Although some software programs learn from user correction, this process is often slow and requires repeated manual adjustments. Improving the accuracy of voice recognition software could reduce the effort needed to correct errors, enhancing the overall user experience.

User Testing. This study also found that user testing with people with upper-body motor impairments is essential for improving assistive technology. Many participants pointed out accessibility issues that developers might overlook without direct feedback from users with upper-body motor impairments. Testing assistive technology with people from the target use group could help researchers and developers identify necessary improvements and address most accessibility issues. As P2 previously mentioned, they had the opportunity to test different types of mice available at their national rehabilitation center. Their experience suggests that real-world testing with people who rely on assistive technology could lead to more effective designs. Involving people with upper-body motor impairments in the development process ensures that usability challenges are properly identified and addressed, leading to assistive technology that better meets users' needs.

Enhancing assistive technology requires direct feedback to address challenges related to customization, voice recognition accuracy, and accessibility. While this study has a limited sample size, the insights gained from participant experiences provide valuable guidance for improving existing devices and developing future innovations in assistive technology.

7. Discussion

The findings of this study highlight significant barriers and opportunities for improving assistive technology devices for people with upper-body motor impairments. Participants frequently cited frustration with the functionality and consistency of their devices, particularly voice recognition software, which echoes the findings by Cossovich et al. (2023) about the usability challenges of co-designed input devices [4]. Polacek et al. (2017), also discussed participants' frustrations with voice recognition software and mouse navigation inefficiencies [13]. However, this study expands on previous research by identifying specific breakdowns in voice recognition software accuracy. These issues include difficulty distinguishing commands in noisy environments, the time required to train commands and functionalities, and the mental fatigue caused by frequent corrections. These insights reinforce the need for user-centered designs as outlined by Hwang et al. (2003) to enhance accessibility [7].

Furthermore, respondents voiced frustration with the accuracy and efficiency of certain software-based assistive technologies, particularly voice recognition tools like Dragon and Speechify, which often required corrections due to errors. Many users found that inaccurate transcription and difficulty navigating commands increased their cognitive and physical effort, making their tools more burdensome than beneficial. These findings support previous research, including Andreas et al.'s (2022) work, which highlights how high error rates and usability challenges contributed to the abandonment of assistive technology devices [2]. The lack of customization and adaptability further exacerbates these issues, as users struggle to tailor the software to their specific needs.

In addition, Li et al. (2022) emphasized the importance of multimodal input options, which accommodate the specific challenges and contexts faced by people with upper-body motor impairments [9]. The survey and interview sessions revealed the variety of assistive technology devices used for laptop/desktop access, showcasing the diverse tools participants rely on in daily interactions. The data also underscore the necessity of flexible customization in assistive technology design, as participants stressed the importance of modifying their devices to suit their conditions and needs.

Makati et al. (2024) emphasized the limitations that overlays impose on users with blind and low vision users experience when using assistive technologies [10]. While this study focuses on people with upper-body motor impairments both groups experience overlapping conflicts and limitations with their devices. Survey respondents reported that overlays often create additional barriers, making digital interactions more time-consuming and frustrating by failing to accommodate their needs.

Avellan et al. (2024) highlighted the importance of interactive, hands-on experiences in raising accessibility awareness [3]. Their research showed that direct engagement with assistive technologies helps participants gain new insights and develop a deeper understanding of accessibility. While accessibility testbeds expose users to assistive tools, my research highlights real-world usability challenges, such as the lack of customization and compatibility issues. These findings suggest that awareness initiatives should pair with user-centered design improvements to enhance assistive technology effectiveness.

This study underscores the critical role of user-centered design in developing assistive technology devices that meet the needs of people with upper-body motor impairments. By incorporating participant feedback and improving device functionality, developers and designers can create new devices that deliver a seamless experience for these users.

7.1 Reflection

While creating the survey, I learned the importance of marking questions as required, as some participants skipped certain questions. Additionally, some participants noted that the survey did not allow them to go back and change their answers, which I had overlooked during the survey design. Furthermore, collecting precise information about the duration of a participant's impairment could be beneficial. The survey used predefined ranges rather than specifying an exact number of years. While this approach provided an overview, it limited data precision. For example, many participants selected the '> 5 years' range layer mentioned in interviews that their impairment had lasted over ten years. Although this may not have affected their responses, knowing the exact duration could offer deeper insight into their. In addition, gathering information about participants' experiences during the early years of having an upper-body motor impairment could further enhance understanding.

7.2 Limitations and Future Work

Initially, I planned to conduct the interview session in-person, along with a short demonstration where participants would show how they use their assistive technology device(s) on a laptop and/or desktop. However, recruiting participants within the Rochester area proved challenging. Some participants within the area expressed difficulty travelling to the RIT campus or felt uncomfortable doing so. As a result, I opted to do the study remotely, which expanded recruitment opportunities.

In place of the images and videos I would have taken; I asked participants to send images of their setup and a short video demonstrating how they navigate their laptop and/or desktop. This approach provided a valuable alternative, allowing me to observe participants in a familiar environment and gain insight into their typical interactions. While this method allowed for possible staging, it also reduced external behavior, allowing for more authentic behavior and interactions.

On the other hand, this approach had limitations in capturing nuanced interactions, such as real-time struggles, fine motor adjustments, and facial expressions during device use. Future work could conduct in-person observation sessions to determine whether results and suggestions remain consistent. A hybrid approach is also recommended, incorporating multiple cameras during live observations to mitigate these limitations while preserving the benefits of a natural setting.

Future studies should explore ways to improve the accessibility of assistive technology devices. This could include enhancing voice recognition software, refining current devices, reducing costs, or increasing awareness of available assistive tailored to users' needs. Exploring more into the experiences of people with upper-body motor impairments will help ensure that assistive technology is designed inclusively and effectively.

7.3 Recommendations

Based on the findings from this work, we make the following recommendations for future design and development of assistive technology. First, accessibility features and testing should be improved by increasing awareness of the different types of assistive technology devices through organizations and support groups. Additionally, continuous user testing should be conducted to enhance the user experience and provide a range of options for different needs. Next, expanding input methods and customization options is essential. This includes developing wearable technology for finger movement or creating more accessible keyboards inputs. It is also important to improve and monitor interactions between software and hardware to prevent issues after updates. Furthermore, reducing the cost of devices, while maintaining high-quality materials is crucial to ensuring affordability. Offering organizational centers or trial periods where people can test devices will help them find a suitable option before committing to a purchase. Lastly, enhancing customizations for users is key. Many respondents and participants suggested a preference for the ability to adjust devices to suit their specific tasks while using a laptop and/or desktop. Additionally, exploring software interfaces designed for various types of upper-body motor impairments and their unique needs would further improve accessibility.

8. Conclusion

In this paper, I explored the barriers, expectations, and opportunities for enhancing assistive technology devices for people with upper-body motor impairments. Thirty-nine respondents completed the survey, and nine participated in an online interview session. Through these sessions, participants expressed satisfaction with their devices but also noted significant challenges, including inconsistencies in voice recognition software, inefficiencies in typing and navigation, and ergonomic limitations. Participants emphasized the need for more customizable and affordable solutions to tailor to better meet their needs. Some suggested adding more features and customization options, implementing chat interfaces on more websites, providing detailed information and tutorials about their devices, and reducing costs. By addressing these challenges and integrating user feedback, future advancements in assistive technology can enhance independence and improve digital experiences for people with upper-body motor impairments.

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Appendices

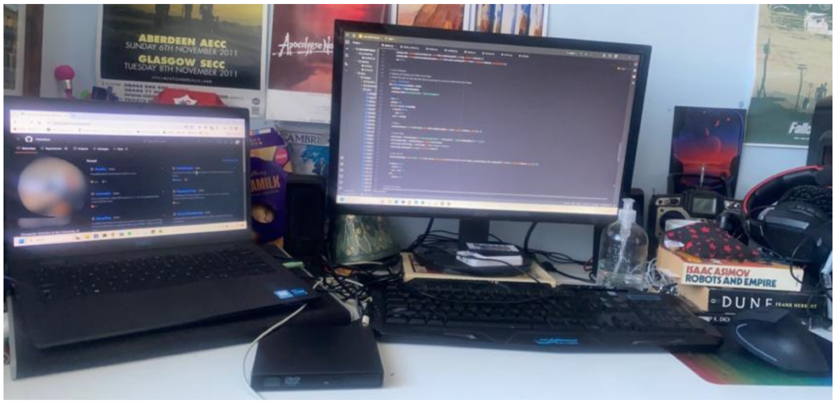

Figure 4. Participant 2 setup using 2.4G Wireless Vertical Ergonomic Optical Mouse.

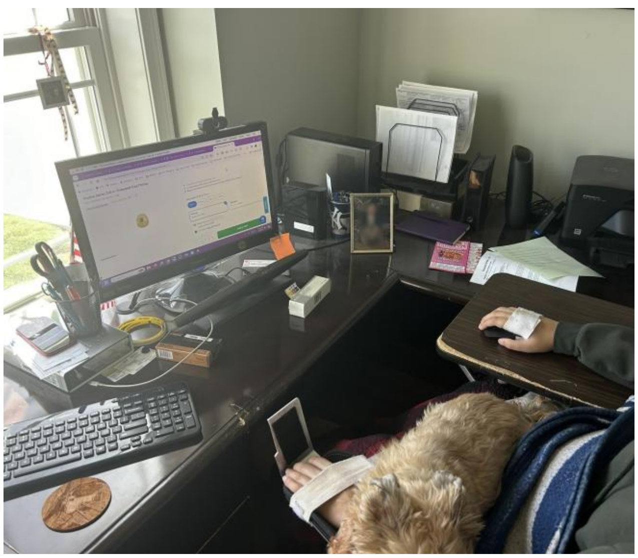

Figure 5. Participant 3 setup using a Bluetooth mouse.

Figure 6. Participant 4 setup using a Plantronics Blackwire headset, Windows Magnifier, NV Access NVDA screen reader, and Nuance Dragon Professional speech recognition.

Figure 7. Participant 4 using a Kingston Expert trackball mouse.

Figure 8. Participant 5 setup with a QuadJoy.

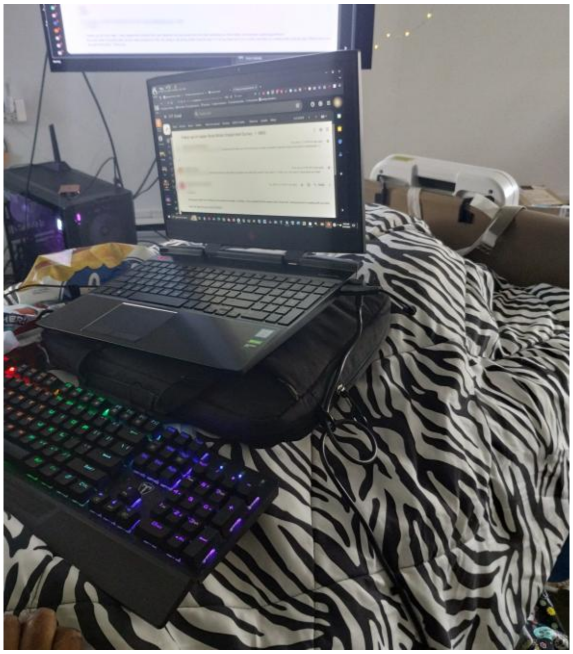

Figure 9. Participant 7 setup using a Windows 11 native app and FastStone Capture software.

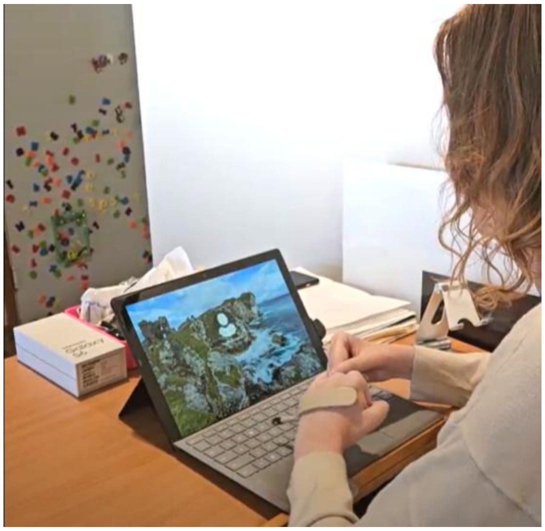

Figure 10. Participant 8 setup using a typing aid.

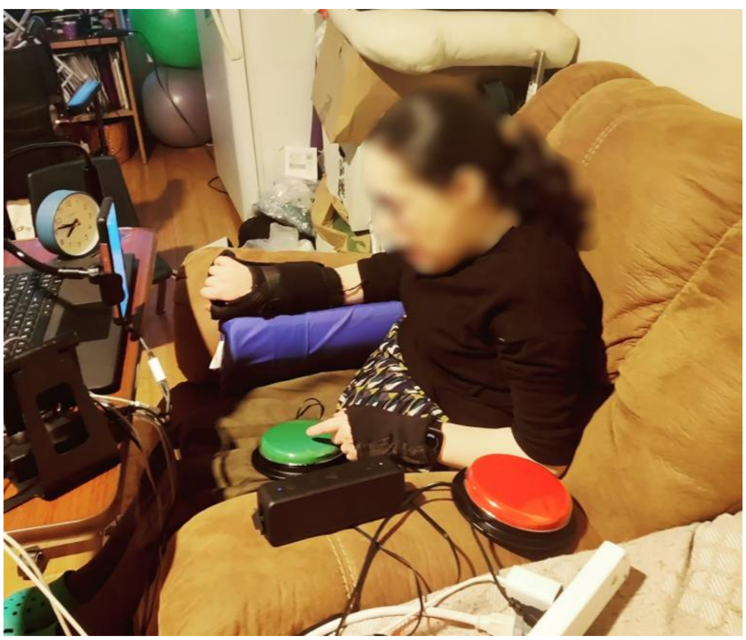

Figure 11. Participant 9 setup using Head tracking (Sesame enable) with two buttons acting as switches.