Challenges Faced by Persons with Disabilities Using Self-Service Technologies

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Contents

Executive Summary

The current state of self-service technology (SST) creates challenges for persons with disabilities (PWDs) regarding SST design inadequacy and how some impairments are being addressed and others not. Specific problems identified in this report for PWDs include the inability to locate SSTs, the lack of privacy and security measures during usage, and the need for universal design. Furthermore, the SST market was analyzed to determine its size and stakeholders. PWDs, businesses, and SST developers were interviewed to gain insight from stakeholders. Using gathered information, areas where universal design has been neglected, causing unequal access, were analyzed to find gaps in current solutions. Finally, SST impacts on society and the economy were reported. PWDs and businesses using SST would all benefit from increased SST accessibility. Though SST have been shown to reduce costs without taking away jobs and generally increase customer satisfaction, there is still work to be done to truly make SSTs universally accessible.

The prevalence of SST across public sectors has increased significantly in the decades since the passage of the Americans With Disabilities Act (ADA). It is crucially important that the inclusion of new, various technological advancements within SSTs continues to consider people with mobility and sensory disabilities, but also that advancements consider a wider array of underserved disabilities such as cognitive impairments. Moreover, impromptu changes in the delivery of goods and services induced by the COVID-19 pandemic that have positively impacted people with disabilities should be considered along with technological advancements when innovating upon SSTs going forward. Moreover, the laws and the standards associated with disability accommodations lack geographical universalization, and at times the imprecise definitions of terms such as “disability” or “reasonable accommodations” contribute to the fluctuating enforcement of disability law across the United States.

Adding smartphone interaction capabilities to SST is becoming an increasingly viable option to allow PWDs to purchase items, access information, and use many of the services that are available to the general public. Smartphones are already a widely accepted technology amongst PWDs and increasing the accessibility of SST through smartphone interaction can provide benefits to both businesses and PWDs. Smartphones utilize various accessible technologies and wireless communication features. Combining these capabilities creates a range of possibilities to work with SST. However, there are still several security and privacy concerns. It is also necessary to note that currently only several SST are explicitly covered under the ADA. Although it may not be required to update accessible options for some SST, there are many business benefits to creating smartphone accessibility such as increasing potential customers and revenue, increasing favorability with the general public, and retaining customers with disabilities.

In order to improve the accessibility of SST technology, specific guidelines of success must be established. There are several key factors that determine the overall accessibility of SSTs. The responses from the interviews showed that ease of use and self-sufficiency were the most important design factors. Stakeholders were also interviewed, these individuals are business

owners who are responsible for implementing the SSTs. Businesses must be incentivized to implement the most accessible technology possible while not sacrificing major financial or other burdens. Finally, shortcomings of previous SST technologies may act as a guide for future technologies in creating new requirements for improvement. Overall, the future of accessibility in SST technology must be directed by guidelines of success to ensure the best possible outcome.

Foreseeable game changing solutions to SSTs will allow for better universal access by better implementing features that are easy and intuitive to use from the inception. Additional robotic advancements will allow for better and easier delivery of goods for consumers. Improvements to artificial intelligence will allow for better communication through natural language and alternative forms of communication. Furthermore, artificial intelligence will aid consumers at SSTs by remembering the consumers preferences and needs. With all foreseeable game changing solutions people with disabilities will be consulted when new and improved SSTs are being developed allowing for the SST to maximize its potential.

Chapter 1: A Review of the Factors Affecting the Adequacy of SST Usage by People with Disabilities

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Introduction

Self-service terminals (SSTs) are used to decrease labor costs and make tasks faster for customers. SST is a general term that includes: kiosks, gas pumps, automated teller machines (ATMs), drive throughs or "drive-thrus", self-checkouts, etc. Figure 1.1 contains examples of commonly used SSTs. The main draw of using SSTs is that it puts the customer or user in control of the ordering and payment process. However, despite their seemingly convenient design, they can be problematic for persons with disabilities (PWDs), thus requiring certain accommodations to be considered (TPGi, n.d.).

(a) Ordering Kiosk (Wikimedia Commons, 2017)

(b) ATM (Mozart, 2020)

(c) Drive Through (Simak, 2021)

(d) Grocery Store Checkout (Swansen, 2008)

(e) Gas Pump (Eckhart, 2015)

(f) Airport Check-In Kiosks (McKelvey, 2020)

Figure 1.1: Examples of Common SSTs

In the United States, 16.5% of the population falls under the 65+ age range (Statista, 2021) and 26% of adults in the US live with a disability (CDC, 2020). In addition, there are also a number of people with temporary disabilities every year due to accidents or injuries. This is a large section of the population that has historically been 'designed out' of being able to easily use SSTs. By implementing more accessible designs, these and many other people would benefit.

Problems Regarding SST Access

Physical Interaction

One main issue that makes SST use inaccessible is being able to physically operate the device. These issues can occur in a wide variety of ways depending on the user's disability as well as the SST in question. Drive throughs for example, present an issue for those who are hearing impaired due to not being able to easily hear the worker on staff, leading to problems with ordering and being able to understand the instructions being given (Hannan, 2013). The menus at drive throughs also present an issue due to often being covered in small lettering and being far away from the reader. Those that have trouble reading or focusing on small things from that distance are often unable to read the menu provided and are forced to rely on past knowledge or hope they can be further assisted in person.

One of the most common features of SSTs, especially kiosks, is the touch screen. Depending on how they are set up, these touch screens can make use of the SSTs much more difficult for a variety of disabilities. The ability to physically press on a screen to input information can often be difficult for individuals with motor impairments or limited use of their hands. The selections are often too small, resulting in either missing the correct input or hitting a different one entirely (Duff et al., 2010). The pressure sensitivity of these devices can also be an issue for people that are not able to provide a strong forceful touch. Similarly to drive throughs, kiosks prevent issues for the visually impaired, often due to small text (Lazar et al., 2019). Icons and pictures have been added to help lessen this issue but it is still very prevalent.

Depending on the user, the positioning of SSTs can also be a problem. Wheelchair users experience significant issues with positioning due to SSTs generally being designed for people who are standing. As such, wheelchair users are not able to easily reach or see necessary parts of the SSTs, such as an ATM having the screen angled upward towards a higher position. Another issue with wheelchair positioning is the reach, depending on how the wheelchair is able to be oriented. At SSTs, such as a self-checkout, the wheelchair user is either forced to pull up facing the screen or sideways if there is no room underneath to pull the chair under. As a result, the user

has to either reach forward or twist in an uncomfortable manner to have access (Bajaj et al., 2006).

Privacy Concerns

SSTs, when not properly implemented for different disabilities, can result in many different privacy concerns. For many that face issues with SSTs, they are required to ask for outside assistance. When using things such as a credit card machine or an ATM, in order to have another person help, the user must tell them sensitive information such as a debit card pin or ATM number, which leads to the possibility of theft (Pino et al., 2014). There have been some methods implemented to convert speech to text at SSTs to prevent another person from getting involved but the user is still stating their private information out loud for anyone to hear. As SSTs currently are and with the vast number of problems often requiring outside assistance, many privacy concerns exist.

Locating SST Terminals

A prevalent problem associated with SST access is the ability to locate terminals. Studies have found that oftentimes facilities like resorts or casinos lack information inquiry counters or proper signage (physical signs) for PWDs to find accessible areas. The lack of signs has proven to be a problem especially for the visually impaired. Facilities often do not have Braille signs, adequate guide blocks, or tactile layout plans to help guide the visually impaired to accessible locations. Such facilities' unwillingness to include such guides or signs is because such signs ruin the atmosphere of their high-end resorts (King Penny Wan, 2013). Lack of such guides and information counters have proven to be a prominent barrier of access for PWDs as they are unable to locate the accessible areas. Furthermore, locating accessible kiosks like ATMs has also proven to be an issue. There are some mobile applications that help with locating SSTs, but they are often limited to locating wheelchair accessible areas in public places rather than accessible kiosks like ATMs. An example of such an application is wheelmap. Wheelmap allows the user to see a map with fully wheelchair accessible, partially wheelchair accessible places, and not wheelchair accessible places categorized and marked. Marked places include public areas including restaurants, public toilets, transport, etc. Unfortunately the application has limitations. The project is crowd-sourced, therefore it largely depends on the users to identify areas of accessibility and share that information with the application. For this reason, for many rural or smaller areas there is not a lot of information available on the application. This is considered to be one of the most developed wheelchair accessible locator applications (*wheelmap,* 2021). There are also similar mobile applications that are more specific to what the user is looking for. An example of this is flush toilet finder, which aids its user in finding a wheelchair accessible toilet. Google has also made an improvement to their navigation application, Google Maps, by adding an "accessible places" option on their application's settings that will display wheelchair icons that indicate accessible locations (France-presse, 2020). A problem associated with many applications is that they are limited towards indicating wheelchair accessible public areas and do not include kiosks or other SSTs or are not other disability aware.

Understanding How to Use SSTs

Another problem associated with SSTs is related to their usability or whether or not it is easy for the users to learn how to use the technology. Many SSTs have been designed after the interfaces of smart phones, so that the skills would be easily transferable. Unfortunately, there still remain gaps between the technology of SSTs and mobile phones interfaces. In a study about

ATMs as SSTs and their accessibility, this issue was evaluated. The study analyzed the usability of SSTs and determined that because the knowledge and experience of the users of SST technology varies largely, assumptions cannot be made when designing the terminal. Additionally, it was found that even users with prior experience with touchscreen technologies face other challenges when using the terminal. These challenges include having limited time to learn how to use the technology, not having all skills from mobile phones directly transferred to using terminals, and difficulty maintaining orientation due to the position of the SST screen. Furthermore, there is not one universal design for accessible SSTs. The design of each varies and therefore can lead to confusion for the user (Jokisuu et al., 2016). The issues associated with the use of a digital ATM can be generalized to many other digital accessible kiosks. In order to ensure that the users understand how to use technology, a human-centered design approach is used. The steps associated with such a process are an early focus on the users and the task at hand, a focus on usability and ease of learning, and finally the testing of the device (Pino et al., 2014). Even though this process is used to design the device, due to the diversity of users and their knowledge and experience, gaps are inevitable.

Lack of Universal Design of SSTs

To understand where the gaps can be found in the current design of SSTs, it is important to know the key aspects of what is known as universal design. Universal design refers to "the design and composition of an environment so that it can be accessed, understood, and be used to the greatest extent possible by all people" (*What is Universal Design*). Once the principles of universal design are understood, the gaps in SST design can be determined.

Universal design is a key component of the engineering process and must be considered for each decision that is made during the creation of an SST. There are seven principles that universal design is based upon, which are the following: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort, and size and space for approach and use (*Universal Design: What is it?)*. These essential principles are summarized below in Table 1.1.

Table 1.1: Summary of the Seven Principles of Universal Design

Principles of Universal Design	
Equitable Use	All users must be able to operate the equipment equally, without any privacy or safety concerns.
Flexibility in Use	The preferences of a user must be accommodated, such as handedness and pace of use.
Simple and Intuitive Use	A simplistic design must be obtained such that it is easy to understand for all users.
Perceptible Information	All users must be able to understand the pictorial, verbal, or tactile information that the device provides (*Disability and Inclusion)*.
Tolerance for Error	Incorrect or unintentional actions should be allowed to occur without serious consequences.
Low Physical Effort	The device should be able to be operated with minimal fatigue of the user.
Size and Space for Approach and Use	The device must be large enough and, in a position such that all users are able to see and approach the device with minimal obstructions

In many cases, SSTs do not accommodate all seven key aspects of universal design, and therefore, are not accessible to many individuals with disabilities. These principles are not

always met in the design of SSTs and can lead to many difficulties when PWDs attempt to use them. One example of an SST design that does not meet the standards of universal design is shown in some voting machines. Although many steps have been taken to ensure easy access to voting machines, little has been done to improve the voting machines themselves. Individuals with mental or reading disabilities may have difficulties reading the prompts on the screen, which leads to higher error rates for these voters (*A Consideration of Voting Accessibility)*. This violates several of the key principles of universal design, including equitable use, perceptible information, and tolerance for error. Some success has been found when the voting machines read the prompts on the screen to the user; however, privacy issues can arise with this method, since others may be able to hear the candidate choices made by the user. Another method to remedy this gap has been the research conducted to determine if button size on SSTs (including voting machines) has an effect on user performance. One of these studies found that individuals with motor control disabilities were significantly less accurate with smaller button sizes than their counterparts without motor control disabilities (Duff et al., 2010). These two factors play a large role in the accessibility of voting machines, leading to lower voter turnout and higher voter error.

Another example of universal design not being implemented in SSTs is shown in ATM devices. One study in particular shows the difficulties individuals with visual disabilities encounter when trying to use ATMs (Omariba et al., 2013). This showed that these individuals need a secure and accessible method to use these devices, since many gaps arise that need to be addressed in order to ensure complete access. Some examples of gaps include the following: challenges locating the ATM, difficulties seeing the screen or PIN numbers, and the potential to be left helpless if any unexpected outcomes arise (Omariba et al., 2013). Again, these gaps violate several aspects of universal design, such as equitable use, perceptible information, and tolerance for error. One method that is currently used to remedy this gap is the introduction of smartphone assistance with ATMs. This technology allows users to authenticate their transactions with their mobile devices, rather than having to use the ATM screen. However, some banks have not updated their technology to this new system, leading to confusion for PWDs, since it is not consistent across all banks.

Although these are just a few examples of the gaps in the current solutions of SSTs, it shows that universal design is rarely followed, especially for those with disabilities. In order to rectify these problems, SST design must consider the principles of universal design and take into consideration the potential challenges that may arise during its use for individuals with disabilities.

Laws Regarding SST Access

SSTs are used for various applications and are expected to be used more in the future. SSTs are seen as a way to decrease the number of human interactions needed to complete tasks and make it easier for people who speak different languages to have access to the same information and services (Bridgwater, 2019). However, while SSTs are typically simple to use for individuals without disabilities, the lack of human interaction can create challenges for PWDs. Additionally, changes made to SSTs that increase accessibility for people with some disabilities are shown to negatively impact people without disabilities and people with other disabilities (Sesto et al., 2011). This indicates that adequate access is a challenging topic to address due to the impact that accessibility measures have on various users.

There are currently laws in place to ensure that PWDs have the same opportunities as everyone else. The Americans with Disabilities Act (ADA) was implemented in 1990 to prohibit

discrimination based on disabilities. This law has five sections, each of which applies to a different part of people's lives. In Title III of the ADA, it states that businesses are expected to provide "reasonable accommodations" for PWDs (National Network, 2021). This vague language has caused many lawsuits to emerge since people have a variety of definitions of reasonable accommodations. For example, there have been numerous lawsuits against fast food chains regarding accessibility that have ended in inconsistent results due to the lack of clarity in ADA requirements. McDonald's faced a lawsuit due to their lack of nighttime accessibility for users who are visually impaired. However, since the plaintiff could not prove he had made attempts to use the drive through at night, the lawsuit was rejected. This same situation could have ended with differing results depending on the judge hearing the case (Kelso, 2019). The subjective nature of the ADA requirements has previously and continues to produce challenges for those with disabilities. In addition to the ADA requirements, the U.S. Access Board and the American National Standards Institute (ANSI) are used as guidelines for adequate access.

The U.S. Access Board Standards and Guidelines contain multiple requirements of adequate access that relate to SSTs. The official document includes details about specific requirements, however it also contains exceptions to the guidelines. Section 508 of the U.S. Access Board Standards and Guidelines states that if any component that complied with the earlier standards has not been changed on January 18, 2018 or later does not have to be changed to conform to current standards. Additionally, when undue burden on the agency would be caused by conforming to standards, the agency must determine the extent of burden that would be caused. When an undue burden would be caused by compliance, the agency must have an alternative method for users to access the information rather than changing the device itself (U.S. Access Board, n.d.). These exceptions to making accessible SSTs impact users of the devices due to their lack of clarity as well as the caveat that if an undue burden would be caused by changing the device itself then an alternative method must be made available to retrieve information. This allows inaccessible SSTs to not violate the U.S. Access Board's Standards and Guidelines, and similar issues arise with ANSI Essential Requirements.

The ANSI Essential Requirements include a stipulation that requests for withdrawal can be made to an American National Standard (ANS) for multiple reasons. One reason for withdrawal of an ANS includes the standard containing unfair provisions. While the requestor is required to provide proof of the unfair provisions, this requirement for withdrawal remains subjective (ANSI, 2021). The combination of the ADA, U.S. Access Board Standards and Guidelines, and ANSI Essential Requirements still contains areas that can cause disagreements about what companies are and are not required to do to guarantee accessibility for everyone. Also, with SSTs being a method to avoid the need for nonessential human interaction, allowing for an alternative method to retrieve information can take away this benefit of SSTs for individuals with disabilities. This leads to the necessary discussion of what should be considered reasonable accommodation and when undue burden outweighs the need for equal access.

Laws regarding accessibility are important to ensure compliance to necessary accessibility standards. However, without clear rules and regulations, they can be hard to enforce. Chapter 4 will discuss recommendations for what should be used to indicate adequate accessibility of SSTs. This chapter will contain details that could be added to accessibility laws to make them easier to enforce and create fewer disagreements on what is classified as adequate access. Additionally, the cost to the companies implementing SSTs must be considered and found to be outweighed by the benefit to the consumers for these guidelines to be accepted. With greater clarity in accessibility guidelines, there would be fewer cases of complicated lawsuits

regarding SSTs. The difficulty associated with such lawsuits is the vague language used, so clarifying the current laws to make them less subjective would allow for easier enforcement.

Stakeholders

There are three main groups of people that are of interest in the development of SSTs: people with a disability, businesses that have these SSTs, and the creators of these devices. According to the CDC, 61 million adults (26%) in the United States have some type of disability (CDC, 2020). As seen in Figure 1.2, there are various different disability types that need to be catered to in creating an SST. Within this group the largest percentage is those with mobility issues. More specifically there are 8.1 million who have difficulty seeing, including 2 million who are blind, 7.6 million with impaired hearing, and 19.9 million who have challenges lifting, grasping, or pressing buttons on a touchscreen interface (NCR, 2021).

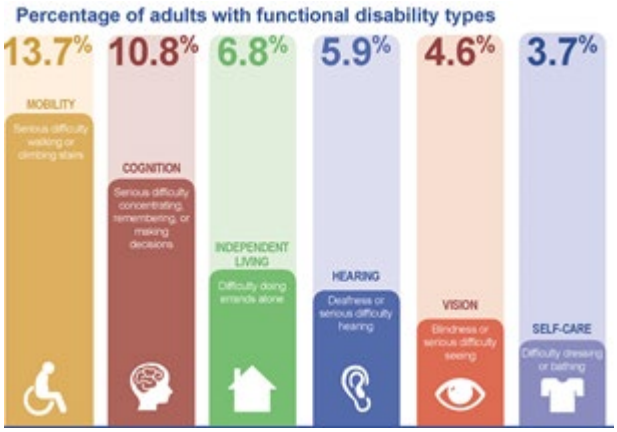

Figure 1.2: A breakdown of the percentage of adults with different functional disability types (CDC, 2020).

While there are issues in the development of SSTs for each of these groups, there are specific groups that are more underserved compared to others. In most locations, the prime accessibility issue that business owners target is mobility, as it does affect the largest group. This is seen in many SSTs as there is often a wheelchair accessible option. However, mobility embodies a wide variety of different physical disabilities that they are not all catered to equally. For example, upper limb and manual dexterity disabilities result in a loss of fine-motor control giving them issues with pressing hard or accurately enough to interact with the correct buttons or a virtual keyboard (Veijalainen, 2017, p. 28). Similarly, in a survey conducted with 6,422 people that are deaf or hard of hearing it was discovered that 78% have had difficulty placing a fast-food order and 42% have left a Drive-Through line in frustration because they were unable to communicate (Hughes, 2004, p. 3). A third underserved population is those that are blind or have visual impairments. As mentioned previously, this is seen in the privacy concerns of current ATM design and the inability to access a drive-through without a vehicle.

From the perspective of retail owners, there are many incentives to have SSTs within their facilities. For example, the retailer can address labor shortages while maintaining high service levels and can enable customers to have easier access to goods and services, with 24/7 access in some cases (NCR, 2021). Though these machines provide greater access, if a retailer fails to achieve ADA compliance then they could receive a fine of up to $75,000 for first violations and $150,000 for subsequent violations (NCR, 2021). However, typically these lawsuits are settled between a couple of thousand dollars and $20,000 (Behnken, 2019). In 2019

there were 11,053 ADA Title III lawsuits filed in federal courts across the nation, which has quadrupled since 2013 as seen in Figure 1.3 (Shaw, 2020). Still, at these high amounts this figure does not include the significant number of disability access lawsuits filed in state courts which are much more difficult to accurately track, making the amount of complaints even higher then what is shown here (Shaw, 2020).

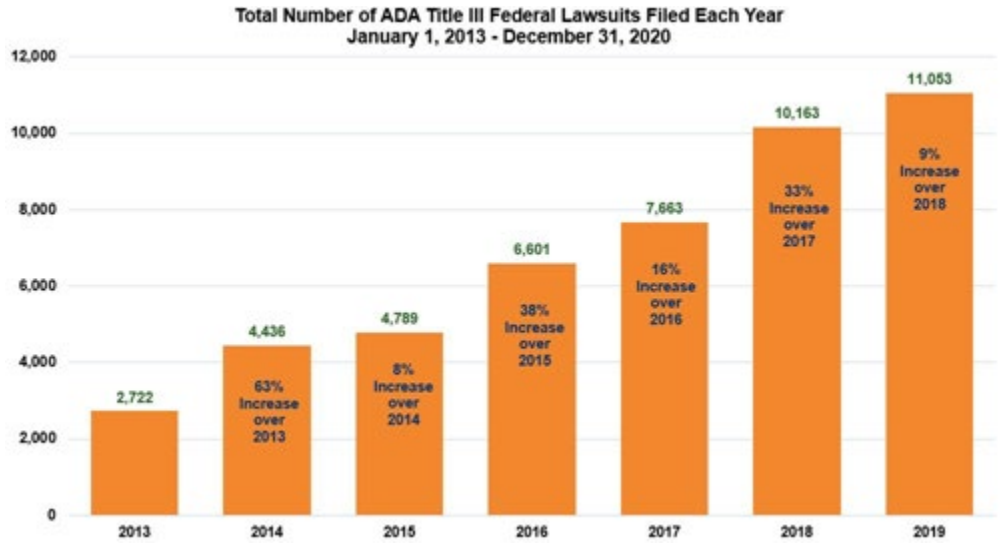

Figure 1.3: Increase in the number of ADA Title III federal lawsuits filed each year from 2013-2019 (Shaw, 2020).

Because of this, the retail owners have a need to create devices that will provide universal access for all. In an article asking 22 stakeholders, including developers and business owners, why many places do not provide universal accessible SSTs there were three main issues that they addressed. The first being that they hold little to no understanding about what requirements are necessary for people with visibility, mobility, or hearing disabilities (Petrie et al., 2014). Because of this, even if they want to provide equivalent access to all their customers, they lack the knowledge that would allow them to provide this access. The next issue stated that business owners were worried about the additional costs that come with making SSTs universal and believed that the market was too small to pay for this issue (Petrie et al., 2014). As mentioned earlier, about 25% of the population has some sort of disability, so, though it is not the majority of the population, there is a need for equal access. Additionally, as ADA regulations mention, it is illegal to not comply with the laws, so some options for PWDs must be provided. The last issue mentioned was the lack of guidance from the affected group. Essentially, these developers do not know what is needed in these machines or drive throughs to provide universal access, so if they had clear guidance from the ADA, for example, it would give them a greater incentive to create these universal SSTs.

When speaking to a Shift Manager that works at a popular fast food restaurant in northern Indiana, it was stated that though they have procedures in place there are still issues that businesses face in the goal to achieve universal access (Personal Communication, April, 2021). An example they gave was about their drive-through set up. Since they have an employee outside taking orders face to face, it allows for a person that is hard of hearing to either point, sign, or write down what they wish to order. However, there are employees that do not know how to deal with the situation and fail to assist the customer. Another example that they gave was how some

guests complain about where handicap parking is placed as it provides limited access for them into the building (Personal Communication, April, 2021). These two examples show that though they have procedures in place to provide universal access, the design and lack of training is not ideal for providing people with adequate access to these resources.

In a similar interview conducted with a Banker, who has worked at a nationwide bank for 10 years in northern IN, they stated the several accommodations that they currently have in their company (Personal Communication, April, 2021). In their ATM design for those hard of hearing, the company has set up a spot for users to insert their headphones. Then for people with visual impairments, they have braille on the number pad, enlarged statement forms that one can request, and the option to increase the font size. Then for those with mobility issues, they have a wheelchair accessible stand for check writing and ATM access. Additionally, this bank has a third party company come into the store once a year to ensure that the ATMs are ADA compliant by taking all the necessary measurements. Similarly to the fast food restaurant employee, this banking location did not have any instances that they could recall where customers complained about accessibility issues. Within this bank's website, there is a location where customers can request special accessibility services as well as submit complaints about their experiences. This is likely because as a big corporation they have the resources to ensure that their customers have access and the resources to immediately address any issues that come forward.

Another stakeholder previously mentioned was the individuals that develop SSTs. In an interview conducted with a customer service employee working for an industry leading computer kiosk manufacturer, it was found that all of their SSTs are ADA compliant and the company is working towards 508 compliance (Personal Communication, April, 2021). However, some of these accessibility features are not automatically included and may require an additional fee. For example, ticket kiosks can include a touchpad and have screen reading, for a person with a hearing disability, though these features may require an extra charge. Typically, the starting price for a kiosk is $10,000 then when adding more features to the SST, like a touchpad, it would add an additional $140 to $150.

Impact

SSTs are generally viewed positively by those without disabilities as they decrease the number of interactions required to have with business attendants. For example, in a 2009 consumer survey, 44% of respondents indicated they prefer using hotel kiosks to check in rather than interacting with the clerk (Castro et al., 2010). Another study showed that the service quality by SSTs is positively related to customer satisfaction in retail (Fernandes et al., 2014). As for those with disabilities, the responses vary; in fact, Americans with disabilities tend to be about three times more likely to say they never go online or adopt self-service technology according to a 2016 Pew Research Center Survey (Anderson et al., 2020). In theory, SSTs would increase accessibility, as oftentimes they have features geared for PWDs, such as headphone jacks, captioning, multilingual options, and large fonts. However, in practice, many PWDs have various issues with current SST designs. For example in a survey conducted by the authors of this report, when asked what features of SSTs are hardest to use, responses included "the screen is tilted upward which means I can't read it from the height of my wheelchair", "it's hard to use speakers in drive-throughs", and "gas station terminals have unclear instructions".

Businesses also tend to have a greater investment in SSTs as it reduces their own costs. For example, in banks, the average cost for an online transaction is merely $0.20, where the average cost of a transaction at a physical location is $4.25 (Castro et al., 2010). At retail stores, self-checkouts can decrease the number of cashiers needed or reassign them to higher value jobs.

However, transitioning from staffed checkouts to self-service ones is not cheap, hence the reason smaller shops continue to use employees rather than machines. The typical SST setup costs roughly $125,000 (Mortimer, 2017). While a study by Forbes reports that 88% of companies agree that kiosks will be the fastest growing customer service channel by 2021 (Bridgwater, 2019), and there are many benefits to these kiosks such as efficiency, availability, and personalization, they are not always created equal. In interviews with PWDs who have commonly used these types of SSTs, it was indicated that improvements to these devices should include having moveable screens, keeping a consistent order of questions between businesses, requiring less clicking, and having the option to video chat.

The economy as a whole benefits from SSTs. The per-capita income growth is one of the most important indicators of a nation's economic well-being, which is largely a function of productivity growth. What has often been called the next frontier in company productivity is the "front office" in which customer service is dealt. Since SSTs are a labor-saving device, the savings they create, as previously mentioned, translate into a more efficient output. It is estimated that if widely adopted, self-service technology would contribute $130 billion to the US economy annually, the equivalent of an additional $1,100 of income per US household (Castro et al., 2010). Furthermore, in one industry report, the 2020 self-service market was valued at $28.01 billion and is expected to reach $68.01 billion by 2026 (Mordor Intelligence, 2020). In contrast, many have argued in the "great automation debate" that the increase in technology, particularly that of self-service technology will reduce employment. However, managers overseeing staffing and scheduling have claimed that staffing levels have remained relatively unchanged since the implementation of self-checkouts were introduced (Andrews, n.d.). This indicates that the integration of self-service stations have little to no effect on typical employment patterns.

While the idea of SSTs is mainly to increase efficiency and give back customer control, some people also find that it has negative impacts when building social contacts or personal loyalty (Turner et al., 2019). That being said, SSTs impact the feeling of social inclusion for both those with and without disabilities, though PWDs tend to experience this impact more often. Of the PWDs we surveyed about how useful they found SSTs, 11.5% stated not all, 11.5% slightly, 34.6% moderately, 38.5% very useful, and only 3.9% found the SSTs to be extremely useful, further proving that there is work to be done to make SSTs more accessible.

Conclusion

This chapter has focused on the current state of SSTs; including problems faced by PWDs, what is looked for to determine whether an SST provides adequate access to PWDs, and what disabilities are most underserved within the PWD population. The problems identified and analyzed for PWDs include the inability to locate SSTs, the lack of privacy and security measures for personal information, and the need for more universal design. Furthermore, the SST market was analyzed to determine its size and stakeholders. To further evaluate the stakeholders, several interviews were conducted with individuals in each of three defined groups: PWDs, businesses, and SST developers. Using this information, current gaps in SST designs were investigated to determine what aspects of universal design were neglected, which lead to unequal access and use. Finally, SST impacts on society and economy were reported in conjunction with testimonials from PWDs. Not only would PWDs be beneficially impacted by the increase in SST accessibility, but so would people without disabilities and the businesses that incorporate this technology. Though SSTs have been shown to reduce costs without taking away jobs and generally increase customer satisfaction, there is still work to be done to truly make SSTs universally accessible.

Chapter 2: Standards and Solutions of SSTs for People with Disabilities: An Examination of the Past and Present Landscape

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Introduction

Since the Americans with Disabilities Act (ADA) was first passed in 1990, rights for individuals with disabilities, especially in public locations, have significantly increased. Title III in the ADA refers specifically to public accommodations and describes the accessibility standards for people with physical impairments (*What Is the Americans with Disabilities Act (ADA)?*, 2021). It also outlines the steps required to accommodate those with vision, hearing, speech, and cognitive disabilities. Although standards, such as those enforced by the ADA, have been in place for over thirty years, people with disabilities face challenges every day, especially with use of self-service technology (SST) and kiosks. The standards will be described in greater detail momentarily, but first, the evolution of kiosks such as ATMs, gas stations, drive-thrus, and other SSTs will be investigated.

History of Self-Service Technologies

Gas Stations

About 55 years ago, the first self-service gas station surfaced at a local convenience store in Colorado after realizing the large profit margin that comes with removing labor costs. The transition to unattended gas pumps was met with opposition on both sides of the spectrum and took nearly 50 years to implement nationwide. Regulatory changes were required, such as fire codes, and it took a gasoline shortage in 1973 for the push to self-service to really accelerate (*The History of Self-Fueling*, 2014). Another challenge in transitioning to self-service gas stations was pay-at-the-pump technology, but despite these issues, the gasoline industry was impacted indefinitely from the transition. Transaction times sped up and various costs were removed from the system. Today, self-service gas is required in all but two states, Oregon and New Jersey (*The History of Self-Fueling*, 2014). Gas station modifications have been made in the last few decades to account for the shift in payment methods (card swipe, chip insert, and contactless) and improve the experience at the pump with TV screens promoting advertisements for the customer.

However, regarding changes made to increase accessibility for the disabled, gas stations have fallen short. After a class action lawsuit in the late 1990s against Shell Oil Products Company, fuel stations were also required to have pump handles and credit card scanners at a height that accommodates users in wheelchairs (Emert, 1998). The transition away from full-service pumps has left many drivers with disabilities unable to refuel due to the challenge of calling for assistance. The ADA now requires that a gas station provide assistance upon request at no additional cost as well as instructions at the pump on how to receive help. An example of a service created by Inclusion Solutions known as "FuelCall" is depicted below in Figure 2.1, which provides a phone number for customers with disabilities to call as well as the hours that pump services are available to those customers (*FuelCall™ Gas Station Access,* 2021). However, when gas stations have only one employee, they are not required to provide service.

The outstanding challenge people with disabilities then face is how to easily identify whether they can receive assistance prior to parking at a pump.

Figure 2.1: FuelCall Service at Gas Stations (FuelCall™ Gas Station Access, 2021).

Drive-Thru Services

The origin of drive-thru services dates back to the 1920s with a restaurant in Texas. Prior to the drive-thru that people are familiar with today, restaurants first began to offer drive up services where a carhop would serve customers in their car. As car culture grew in popularity in the 1950s, the chain "In-N-Out" offered the first complete drive-thru in California (Barksdale, 2021). The restaurant industry today was hugely impacted by drive-thru services that included changing food options and modifying car design. Other industries, such as banks and pharmacies, also offer drive-thru services for customers. However, drive-thrus present issues for people with disabilities who have limited mobility in the vehicle, and especially for those who are deaf and hard of hearing. It is important for restaurants to have a clear plan in place to accommodate these customers at the drive-thru window, such as picture menus, pen and paper, or an interpreter readily accessible.

Furthermore, customers with mobility or visual disabilities that require services in store are faced with challenges when drive-thru is the only option, such as late at night or during unprecedented times (for example at the start of the COVID-19 pandemic). In 2019, a class action lawsuit was filed against Taco Bell that stated the fast-food chain was violating the ADA by only allowing late-night orders to be placed through drive-thru windows (Castrodale, 2019). Other restaurant chains have faced similar lawsuits regarding accessibility of drive-thrus, such as Wendy's and McDonald's. One existing solution by Inclusion Solutions, known as OrderAssist™ assists those who are deaf or facing other communication barriers at the drive-thru, and has been implemented at a number of Culver's locations. The product features a patented bell system, signage, and other materials that allow the company employees to efficiently assist disabled customers and is pictured below in Figure 2.2 (*OrderAssist™ Drive-Thru Access*, 2021). Recent innovation in restaurants due to the lack of in-person dining options may benefit customers with disabilities. Features such as curbside pick-up and third-party delivery services of products and goods allow the customer to place an order on their mobile device via an app or a call and receive the order from an employee without leaving their car or house. This increase in options for service from restaurants and other storefronts is beneficial for people with disabilities, but challenges are still encountered.

Figure 2.2: OrderAssist System (Gerhardt, 2011).

Automated Teller Machines (ATMs)

Another form of kiosk that humans interact with on a daily basis are automated teller machines (ATMs), which were invented almost 70 years ago and have drastically impacted the way people bank. Despite the inevitable shift towards a cashless world, ATMs offer secure and quick services, and the technology has been adapted to provide full banking services as well as distribute other products such as movie tickets and stamps. Advancements since the invention of the ATM include video ATMs, which create a virtual experience for the customer with the teller, drive-up ATMs (similar to a drive-thru described previously), and, more recently today, cardless or touchless ATMs that can be interacted with using a smartphone (Wack and Kline, 2017), which will be discussed and Chapter 3. Specifically with regards to the pandemic, many ATMs attempted to transition to a touchless interface to combat any concerns with COVID-19 spread.

Regarding modifications that have impacted those with disabilities, ATMs have shifted to including a talking feature rather than a braille keypad which benefits blind and low-literate users greatly. Another important consideration with user interfaces like those on ATMs (and sometimes gas station payment terminals) is the effect of a shift from physical keypads to touch screens on those with disabilities. These advancements may negatively affect those that experience difficulty without a tactile interface (i.e. blind, limited mobility, motor skills), which will be described from an interviewee's personal experience in further detail in the following section related to vision impairments. On the other hand, the move towards more interaction between smartphones and ATMs could be beneficial for the community with disabilities because of the large amount of assistive technology that exists on smartphones (Pous et al., 2012).

Voting Booths

The final self-service technology that will be investigated in further detail is voting booths. Historically, voting has been a process completed in person, but within the last decade the number of mail-in voters has increased significantly. Especially notable is the 2020 election, which saw an increase in early and mail-in voting due to the pandemic, accounting for over half of the primary votes cast. This increase in absentee and mail-in voting nearly doubled the previous general elections, as shown in Figure 2.3 (Desilver, 2020). This election will likely affect voting methods in the future for populations that may not have participated in mail-in voting in the past.

Accommodations for in person voters who have disabilities were adapted from Title II of the ADA, which ensures people with disabilities have physical access to the polling location and voting area, auxiliary aids and/or materials in other formats (such as interpreter services), and

other reasonable accommodations which include curbside voting or voting from home (Pendo, 2020). Despite these measures, voters with disabilities still experience barriers in the process, which will be discussed in further detail in the following sections. Moreover, those with disabilities prior to the 2020 election are significantly more likely to cast a mail-in ballot but also significantly less likely to vote. This data suggests that continuing to increase accessibility as in-person voting processes evolve with technology will likely not affect the voting turnout among those with disabilities (Miller and Powell, 2016).

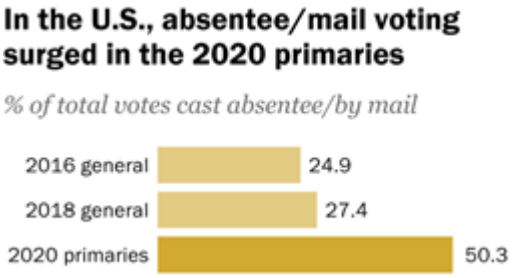

Figure 2.3: Graph Depicting Increase in Absentee/Mail-in Votes in 2020.

Current SST Accommodations

Not all disabilities require similar accommodations, and flexibility is an important factor. Figure 2.4 depicts the range of disabilities present in the United States by age, sex, and disability type as surveyed by the U.S. Census Bureau in 2018. The following subsections highlight some current accommodations and challenges faced by people with these various disabilities.

Figure 2.4: Number of Americans with a Disability by Age, Sex, and Disability Type (United States Census Bureau, n.d.).

Mobility Impairments

The U.S. Census Bureau estimates that 19.9 million people have challenges involving mobility, including lifting objects and selecting buttons on an interface similar to those used on SSTs (*How to Offer More Self-Service Kiosk Accessibility and Better Experiences for Customers with Disabilities*, n.d.). The prevalence of these challenges and the use of wheelchairs or other wheeled mobility devices in the community indicate the need for accommodations. Therefore, people sitting must have the same access to technologies as those typically developed for and used by standing customers. Common barriers to be overcome for mobile disabilities are as follows: a wheelchair must be able to get close enough to the device and access space must not be too narrow. As specifically described by the ADA guidelines, this ground space must include at least 30 inches by 48 inches of accessible ground before the kiosk. The kiosk interface must be within 15 to 48 inches from the ground and floor space must be cleared at least 30 by 48 inches before the kiosk in order to remain accessible. Keypads must face normal to the interface or sideways from their wheelchair so they can easily be seen (*How to Offer More Self-Service Kiosk Accessibility and Better Experiences for Customers with Disabilities*, n.d.). An evaluation of the design standard in the UK considers the key features that make accessibility for wheelchair users more difficult. Keyboards and similar user interfaces should be easy to see and reach. The same study ran simulations of varying designs and confirmed that adjusting the orientation of these buttons to an angle more accommodating to consumers in a wheelchair can still be seen by over 95% of males without bending or stooping. This is an improvement from the initial design of less than 50% accessibility for users in wheelchairs (*An Ergonomics Approach with Special Reference to the Needs of the Disabled Person,* 2000). Additionally, privacy is a concern that must also be granted along with these other amenities. A headphone jack must be accessible for use with audio prompts and sound output if desired ("2010 ADA Standards for Accessible Design," n.d.).

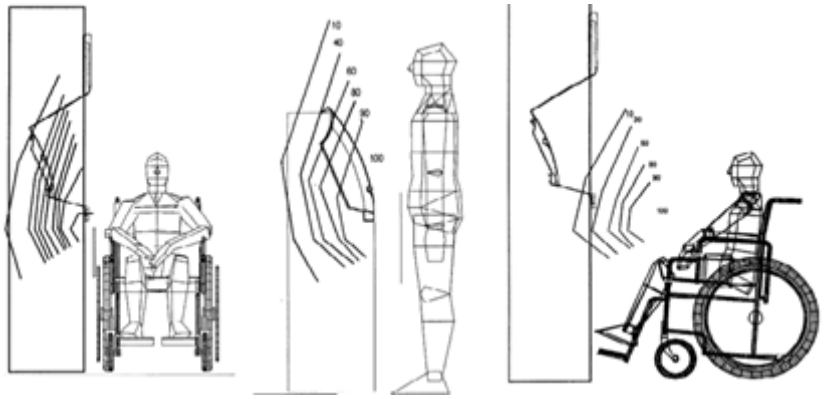

Figure 2.5: Past SST Designs That Are Deemed Inaccessible to Wheelchair Users (An Ergonomics Approach with Special Reference to the Needs of the Disabled Person, 2000).

A college professor with a mobility impairment in all four limbs due to a spinal cord injury and who uses a power wheelchair shared some of the challenges he faces both daily and in specific circumstances. As he discussed in an interview, his general experience with SSTs is difficult largely due to interfacing information and reachability. As a user in a wheelchair, he finds it difficult to get enough knee clearance or reach the screen without turning sideways. Additionally, touch screens are not reliable and features such as card swiping, money

withdrawal, and picking up items from a drive-thru can be increasingly difficult (Personal Communication, March 19, 2021).

SSTs have become increasingly prevalent in society. Self-checkout counters alone were expected to occupy more than 25% of the retail market 15 years ago before 2006 ("2010 ADA Standards for Accessible Design," n.d.). Often, a greater number of self-service checkouts are available than those with customer assistance, even though the range of mobility these SSTs demand make them inaccessible to people with disabilities. Issues with these types of SSTs include components that are not within reach and inadequate knee clearance for wheelchair approach.

Another interview was conducted with a lawyer who has a genetic disease known as osteogenesis imperfecta. With bones that are brittle and break easily, he is unable to bear much weight and utilizes his wheelchair for transportation. As an independent adult, he has yet to use an ATM and does not access drive-thrus, as they do not accommodate for his limited reach and mobility impairment. Beyond his limited reach is the mere issue of positioning. He is not the first to mention difficulties with card swipes and similar user interfaces. These technologies require a certain bend of the wrist, or other contortion that is unnatural and uncomfortable for someone residing in a wheelchair. These SSTs have yet to be updated and redesigned to meet these needs (Personal Communication, March 24, 2021).

Cognitive Impairments

A commonly overlooked disability when considering SST design is cognitive and/or developmental disabilities. Aids such as "flash-videos" giving instruction for use beforehand could be particularly useful for people with these kinds of disabilities, while also being an unnecessary use of time for those without these disabilities ("2010 ADA Standards for Accessible Design," n.d.). Cognitive disabilities have been recognized as one of the broadest areas and most variable disabilities, in which accommodating for them can be especially difficult. However, user interfaces have already been designed for people who are illiterate, and progress continues to be made. An increasing number of icons and speech are integrated into the text for both input and output information ("2010 ADA Standards for Accessible Design," n.d.). Currently, SSTs are not inclusive of this specific type of disability as it is likely difficult to accommodate people who are literate and illiterate in one interface. These challenges are yet to be addressed.

Vision Impairments

In the United States, approximately 12 million people over the age of 40 are visually impaired. This includes 1 million who are blind, 3 million who have a vision impairment with correction, and another 8 million who have a vision impairment due to not correcting even though correction is possible ("Fast Facts About Vision Loss," 2020). By 2050, these numbers are expected to double (Varma, 2016). Vision loss does not only affect older adults. Approximately 3% of children younger than 18 years old are blind or visually impaired. In general, visual disability is among the top 10 disabilities for adults 18 years and older and is one of the very top disabilities among children ("Fast Facts About Vision Loss," 2020). Figure 2.6 shows the global breakdown of causes of blindness, with cataract (39%) and refractive error (18%) being the leading causes.

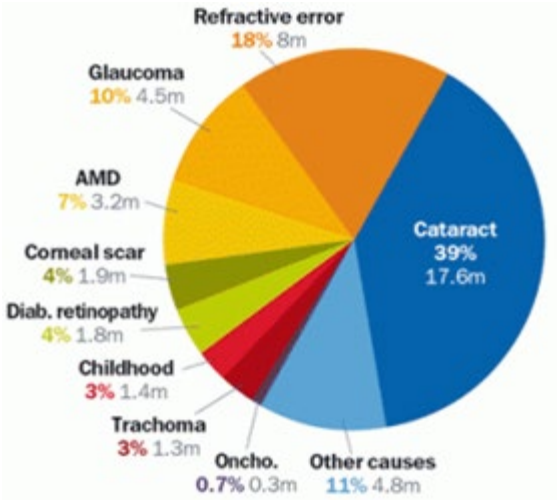

Figure 2.6: Proportion of Cases of Blindness Due to Each Major Cause (Foster et al., 2008).

One type of SST that includes accommodations for the visually impaired are ATMs. As touchscreens are becoming more widely used in many technologies, accessibility issues arise for people with disabilities, especially those who are visually impaired since tactile features on SSTs like ATMs are so important (Jokisuu et al., 2016). Over 100,000 ATMs in the U.S. can be operated using speech, and at most major banks, the only ATMs available are accessible ones. Headphones are required to switch the ATM into accessibility mode to help those with visual impairments perform banking transactions securely and without the need for assistance. Specifically, audio instructions are provided for the user to know the keypad layout ("Accessible Banking", n.d.). Emerging solutions to improving ATMs for people who are visually impaired exist, like how researchers tested four different PIN entry concepts, which consist of taps and swipes as well as tactile markers and discovered that tactile markers on the touchscreen helped users (Jokisuu et al., 2016).

One interviewee, who was born with glaucoma and has had very limited light perception from a young age, shared numerous daily complications that they face because of their vision disability. The largest of these challenges included an overall lack of independence (especially with transportation) and a lack of access to information. They further shared that the ATMs they have used have audio systems that work but are not spectacular, and those with touchscreens instead of traditional buttons and keypads are especially difficult to use (Personal Communication, April 9, 2021).

In a similar manner to ATMs, voting machines use an audio interface so that people who are visually impaired can use them (Piner and Byrne, 2011). These machines are called DREs (Direct Recording Electronics) and take longer to use, 31 minutes compared to five minutes by sighted voters, but have similar error rates (~2%) between voters who are sighted and visually impaired. In Piner and Byrne's study, only 34.4% of the 202 participants stated that they would choose a Braille over an audio interface. They also found that most participants have received assistance from the poll workers with voting at some point, so the DREs are not always entirely independent (Piner and Byrne, 2011). However, voting works "reasonably well" according to the interviewee with glaucoma, even though it is tedious and difficult to vote as quickly as a person without a visual impairment would (Personal Communication, April 9, 2021).

Hearing Impairments

In 2017, it was estimated that 11,270,650 people in the U.S. have hearing difficulty, but people who are deaf have not been counted as a separate category by the U.S. Census since 1930, so there is conflicting data on exact statistics (McLeod, 2019). Hearing loss increases with age, as shown in Figure 2.7 where close to 25% people 60-80 years old experience hearing loss.

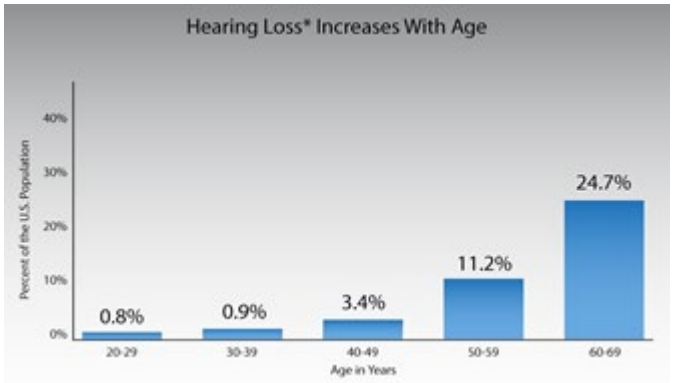

Figure 2.7: Hearing Loss Increases with Age (National Health and Nutrition Examination Survey, 2011-2012).

A survey conducted by Inclusion Solutions in 2004 found that 42% of the 6,500 people surveyed who are deaf or hard of hearing were so frustrated with drive-thru restaurants that they left the drive-thru without purchasing anything (McLeod, 2019). Several of the people surveyed by the authors of this paper pointed out that their most common difficulty with SSTs is being able to hear the employee of a restaurant through the speaker of the drive-thru system. An interviewee with hearing loss has used hearing aids for the past year after a failed surgical procedure to restore hearing. They shared that their hearing aids assist with face-to-face interactions such as drive-thrus (Personal Communication, April 16, 2021). However, for those with hearing loss who do not have adequate assistive technology, services like drive-thrus can be very irritating. To avoid these frustrating times, there are several accommodations that fast food restaurants use to enhance communication with their patrons who are deaf or hard of hearing and are using the drive-thrus. The U.S. Department of Justice recommends other people facilitating communication, such as interpreters or real-time captioners, physical materials, like special menus and assistance call buttons, or technological methods, like automated captioning (McLeod, 2019). For example, as previously mentioned, there is a system called OrderAssist in which customers can press a button that alerts the employees, then they pull up to the window and can write their order (Hannan, 2013). An example of an OrderAssist system at a fast-food restaurant drive-thrus is depicted above in Figure 2.2.

An innovative solution that is nearly finished and in beta testing is The Oublié, a software developed by the company Juke Slot, which consists of a self-ordering kiosk at a restaurant and has the ability to have sign language as the interfacing language. It translates all of the menu options into sign language, and it reduces the occurrence of having to write down orders on paper and pen. This helps those with hearing impairments as the average person who is deaf reads and writes below a fourth grade level, according to McHugh (Maras, 2017). Examples of self-ordering kiosks by Juke Slot are shown in Figure 2.8.

Figure 2.8: Juke Slot Self-Ordering Kiosk Examples (Juke Slot, n.d.).

To conclude the description of current accommodations in SSTs for people with disabilities, it was found that different SSTs can benefit from technology advancements. In the survey conducted by the authors of this paper, a question was asked about this technological improvement allowing for easier use, better accessibility, or greater universal access, and the distribution of answers by SST can be seen in Figure 2.9 below:

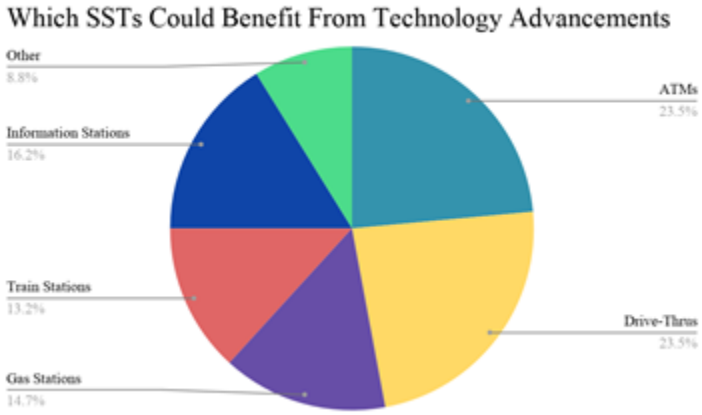

Figure 2.9: Survey Answers for SSTs benefiting most from Technology Advancements (April 12, 2021).

As seen in the figure above, about half of the people surveyed said that ATMs and Drive-Thrus could benefit the most from technological advancements, and these SSTs and their current accommodations for people with visual and hearing impairments were just described. As technology and SSTs continue to evolve, it is crucial to consider a great range of disabilities when making SSTs accessible for everyone.

Legislation and Enforcement of Accessibility Standards

Although the previous chapter briefly mentioned several disability legislation and accessibility standards regarding SSTs, the following sections focus on assessing the standards and protocols in place for introducing and enforcing such laws regarding inclusion for people with disabilities. Understanding who is involved in the lawmaking process and how it is completed will better explain the regulation and where additional attention and enforcement may be needed. There lies a gap in the administration of accessibility standards and how companies choose to abide by them. With this information, one can obtain the knowledge from both the perspective of companies and the lawyers that deal with the lack of enforcement.

Disability Legislation Regarding SSTs

In the U.S., there are approximately ten federal civil rights laws that directly address the interests of people with disabilities. Of these ten, four serve as the primary templates from which federal guidelines and standards for SSTs are derived. In chronological order of their passage, these include The Architectural Barriers Act (ABA) of 1968, The Rehabilitation Act of 1973, The Americans with Disabilities Act (ADA) of 1990, and The Telecommunications Act of 1996. Each federal law addresses unique concerns for people with disabilities and provides a federal baseline of disability accommodations that, in part, specifies accessibility standards for SSTs. These federal laws and their ramifications will be examined further in subsequent sections.

The Architectural Barriers Act of 1968

The Architectural Barriers Act (ABA) of 1968 is one of the first acts that directly outlined accessibility standards for SSTs in the built environment. The ABA stipulates that all buildings constructed or altered after September 2, 1969 that are financed by the federal government and intended for public use must meet accessibility specifications generated by various federal agencies named in the law (*Architectural Barriers Act (ABA) | U.S. Department of Labor*, n.d.). This includes transparently federal buildings such as post offices, national parks, federal courthouses, and federal prisons, but also includes non-federal facilities that were financed in whole or in part using a grant or loan made by the U.S., including public transit networks or public housing (*Architectural Barriers Act (ABA)*, n.d.). As for generating the accessibility specifications, the General Services Administration (GSA) may prescribe standards not already stipulated by either the Department of Defense (DoD), the Department of Housing and Urban Development (HUD), or the U.S. Postal Service (USPS). As it pertains to SSTs, updates to this act provided standards for automatic teller machines (ATMs) and other fare machines. It excluded any other interactive transaction machines (ITMs), which are addressed in subsequent acts. The standards to which ATMs and other fare machines must adhere to as outlined in the ABA are summarized in Figure 2.10 below ("Chapter 7: Communication Elements and Features," 2015):

I. Clear Floor or Ground Space
II. Operable Parts
    I. Each operable part should be able to be differentiated by sound or touch
III. Privacy
    I. Same degree of privacy should be afforded to all individuals
IV. Speech Output
    I. Instructions as well as other functions such as selling tickets or providing copies of statements should be available as speech output
    II. User Control - Speech should be able to be repeated and volume control should be available
    III. Receipts – Speech output should be provided for information on printed receipt
V. Input
    I. Input controls – at least one tactile input control should be provided per function
    II. Numeric keys should be arranged in 12-key ascending or descending layout
    III. Function keys should be contrasted from background and have set tactile symbols
VI. Display Screen
    I. Visible from 40 inches away and characters should be in 4.8 minimum, sans serif font
VII. Braille Instructions

Figure 2.10: ATM and Fare Machine Standards Summarized From Architectural Barriers Act ("Chapter 7: Communication Elements and Features," 2015).

The Rehabilitation Act of 1973

The next major piece of federal legislation after the ABA was the Rehabilitation Act of 1973 (Rehab Act). As it pertains to SSTs, Section 508 of the Rehab Act ensures equality in access for both members of the public with disabilities and federal employees with disabilities to federally disseminated information and data. This includes access to "self-contained, closed products." These types of products are defined by the act as "products that generally have embedded software and are commonly designed in such a fashion that a user cannot easily attach or install assistive technology" (*U.S. Access Board - Revised 508 Standards and 255 Guidelines*). Examples given that meet these criteria included SSTs such as information kiosks and information transaction machines. Section 508 of the Rehab Act specifies many different qualifications federal SSTs must adhere to. This includes requiring, among many other things, alternate forms of identification when biometric forms of identification are used, specifications regarding audio output including privacy and decibel thresholds when in public or otherwise loud environments, restrictions on color coding, specifications regarding adjusting color and contrast settings, and bounds in hertz on the frequency at which the screen can flicker. Moreover, this subsection also includes specifications regarding the distance of operable controls horizontally from the user (Figure 2.11a) and vertically from the user (Figure 2.11b) as shown below (*U.S. Access Board - Revised 508 Standards and 255 Guidelines*):

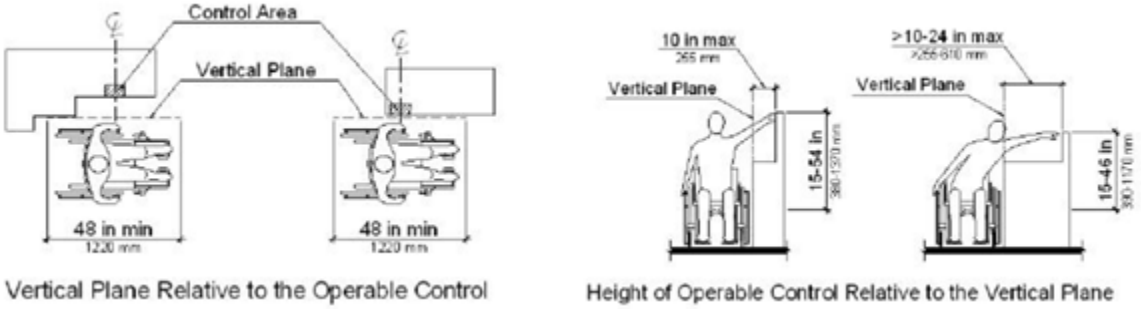

Figure 2.11a & 2.11b: SST Specifications in the Rehabilitation Act of 1973 (*U.S. Access Board - Revised 508 Standards and 255 Guidelines*).

Finally, five years after the passage of the ABA, Congress noted that no federal initiatives to design and implement accessibility standards as outlined in the ABA had begun. Consequently, the Rehab Act created the U.S. Access Board - originally the Architectural and Transportation Barriers Compliance Board - to invent and enforce accessibility standards in the spirit of the ABA (*U.S. Access Board - Rehabilitation Act*, n.d.).

The Americans with Disabilities Act (ADA) of 1990

In 1990, a landmark bill was signed into law, the ADA, that significantly expanded upon prohibiting discrimination for people with disabilities in many facets of public life. Enumerated in Titles I-IV, these facets include employment, state and local government, public accommodations, and telecommunications, respectively. Title III of the ADA is the subsection of the law that converges most with ensuring the accessibility of SSTs. Title III — the public accommodations subsection — ensures that private entities that own, lease, or operate places of public accommodation do not discriminate based upon disability (*A Guide to Disability Rights Laws*, n.d.). A public accommodation is defined as an entity whose operations affect commerce. A partial list of public accommodations includes hotels, restaurants, lecture halls, grocery stores, gas stations, terminals, libraries, zoos, and homeless shelters. In Title III, public accommodations

are instructed to provide individuals with disabilities "auxiliary aids and services" to be able to effectively interact with the accommodation (*U.S. Access Board - Americans with Disabilities Act*, n.d.). In 1991, when the law was originally crafted, not many SSTs existed. Thus, it did not include an exhaustive accounting of them in its original definition of "auxiliary aids and services." However, in 2010, the ADA was revised by the Department of Justice to include more SSTs under its scope, expanding the breadth of "auxiliary aids and services" to encompass "accessible electronic and information technology" (Vu & Sarnoff, 2017). Unfortunately, the only SSTs for which there are specific technical standards are ATMs, fare machines, fuel dispensers, and vending machines. All other SSTs only fall under the broad term of providing "reasonable accommodations," a shortcoming of the law that will be further explored in the subsequent section on enforcement gaps (Vu & Sarnoff, 2017).

The Telecommunications Act of 1996

The final bill that will be briefly summarized is the Telecommunications Act of 1996. This act specifies that manufacturers of telecommunications equipment must make their services and technology accessible by people with disabilities. A wide swath of public telecommunication goods such as cell phones and operator services were required –if readily achievable– to become accessible to those with disabilities. With the exponential growth of digital and handheld communication technology in the 21st century, this act ensured discrimination could not be extended into the technological domain. This is vitally important for the future accessibility of SSTs because technological advancements appear to be headed toward the integration of mobile devices and other assistive technology mediums with SSTs. As long as legislation is present in the form of the Telecommunications Act, it can be better ensured that mobile and other handheld telecommunication devices properly allow for people with disabilities to interact with various self-service technologies that are built to integrate with outside devices (*A Guide to Disability Rights Laws*, n.d.)**.**

U.S. Access Board

As first outlined in the Rehabilitation Act of 1973, the current standards are created and run by the U.S. Access Board, which is a federal agency that advocates for equality for those with disabilities through creating accessibility standards and guidelines. The Access Board controls the design and development of federally funded facilities including some Self-Service Technologies (SSTs). The Board consists of personnel from federal agencies and those who can directly represent the public, especially the sector of those with disabilities (*U.S. Access Board - About the U.S. Access Board*, n.d.)**.** Through the strong diversity of the Board members, the Access Board is able to identify where and how new standards need to be created and upheld. As more amendments and acts were established, the Board expanded their mission to assure that disabilities were taken into account in many public and private facilities for the general population (*U.S. Access Board - Board History*, n.d.). In addition to the complaints and information directly received by the Access Board, the World Health Organization (WHO) also plays a role in identifying disability as a public health issue and providing adequate resources to account for people with disabilities. WHO describes the interaction of people with disabilities with personal and environmental factors to better advocate for such people and areas where there is a lack of attention and in turn a range of barriers that such populations face (*Disability and Health*, n.d.). With such organizations making progressive contributions in bringing awareness to problems that people with disabilities face, the Access Board has additional opportunities to reflect on them and make the necessary changes in their standards.

Developing New Standards

The process of developing new standards and enforcing them in the U.S. is a course which is outlined in one of the first and most important disability standards: the Americans with Disabilities Act (ADA). *U.S. Access Board - Rulemaking Process*, n.d.). These steps help to create a sustainability plan for the rule and to allow enough parties to come together to create and approve the rule with care. An interviewee, who is a member on the U.S Access Board and a practicing lawyer described the difficulty in developing these standards. The interviewee outlined that only a small fraction, $9 million of government allotted funding is received by the Board. Due to the lack of appropriate funding, much of this money is used towards research and hence makes the process of creating standards a lengthy one (Personal Communication, March 24, 2021).

Enforcement of Standards

Enforcement Mechanisms

Although there are several government agencies that enforce and regulate various accessibility standards for SSTs, this section will focus on which government agencies regulate and enforce the pertinent sections of The ADA of 1990 and the Rehabilitation Act of 1973. As mentioned before, Title III of the ADA focuses on ensuring equal access of SSTs to those with varying disabilities. The U.S. Department of Justice (DOJ) holds the predominant enforcement responsibility regarding Title III of the ADA regulations. The DOJ assures that people with disabilities are not discriminated against and have appropriate accommodations when utilizing SSTs within a public setting (*Americans with Disabilities Act | U.S. Department of Labor*, n.d.). Also, as previously mentioned, Section 508 of the Rehabilitation Act of 1973 requires that federal agencies allow their information and communication technology, such as information kiosks, to be accessible to people with varying disabilities. While the U.S. Access Board continues to update the standards within this section of the Rehab Act, the Civil Rights Center (CRC) enforces the complaint provisions of this section. The CRC ensures that people with disabilities are not being discriminated against and have equal opportunity to access the publicly available information and services (*Laws and Regulations | U.S. Department of Labor*, n.d.).

Case Studies

Despite the existence of governing boards and federal legislation to account for a means of accessibility for people with disabilities, there still lies many issues with companies abiding to these standards with their SSTs. Many technology based services are determined by the interest of people who are working professionals or in the commercial sector. However, a key perspective regarding disability movements is not considered in the development of such technologies (*JOHNSON and MOXON*, 1998). Several lawsuits have arisen over the past few decades against companies and their inability to have accessible technology. Despite the lawsuits, some companies do not see merit in these cases and have been able to continue their practices unabated.

The most prominent area of lawsuits regarding SSTs is with fast food drive-thrus and their lack of attention for accommodating people with disabilities. Although issues still remain with kiosk accommodations for people with impairments, the mere introduction of kiosks has greatly helped to bridge the gap. However, these kiosks are only available inside of fast food stores, and the people who benefitted from them are now unable to access these facilities during the current covid 19 pandemic and cannot rely on drive-thrus due to their inaccessibility. As mentioned previously in the beginning of the chapter, Taco Bell was recently sued for having a

late-night drive-thru only service which is discriminatory to those with visual impairments or the inability to drive. The federal lawsuit claims that this guideline by Taco Bell violates the ADA since it prohibits serving customers who walk up, rather than drive up to the drive-thru. Without the option to enter the store, people with such disabilities do not have another option. The intention of this lawsuit is to remove the "drive-thru only" service or remove the clause that does not allow pedestrians to walk in the drive-thru to order food (*Taco Bell Lawsuit Reflects Tech's ADA Challenges*, n.d.). Although this specific case has not concluded with a ruling yet, many other fast food chains including McDonalds, Wendy's, and KFC have dealt with similar lawsuits resulting from gray areas within their own accessibility accommodations.

Additionally, the lack of accessibility and usability of standard kiosks for people with disabilities, mainly visual and mobility impairments, has led to several extensive lawsuits against technological businesses. Initially, the addition of kiosks has greatly helped to alleviate the accessibility problems for those with communication disabilities. On the other hand, the kiosks have been acknowledged as an inconvenience to those with visual and mobility impairments. In 2014, Redbox settled a class action lawsuit with individuals who are blind and a blind advocacy group. Redbox was sued for not allowing individuals who are blind to independently use their DVD self-service kiosks which were deemed inaccessible and discriminatory to those who are blind. The kiosks did not incorporate any assistive features that would allow a person who is blind to independently and properly use them. Therefore, Redbox was required to make several accessibility improvements to their kiosks and pay millions of dollars in damages (*Accessible Technology*, 2014). This lawsuit is just another example of how businesses face detrimental litigation when they provide SSTs that are not completely accessible for consumer use. Moving forward, it is necessary for businesses to consider how accessible their SSTs are for individuals with various disabilities.

Enforcement Gaps

Although there are several federal government agencies that help enforce and regulate the various standards for people with disabilities, there is a lot of variability in how exactly they are enforced. This variability occurs since each state and local government interprets these federal regulations differently and has their own civil rights laws. These federal laws and regulations are seen as federal guidelines and as long as they are not strictly violated, state and local governments have the ability to interpret and enforce them as they wish. This results in the federal laws and regulations not being standard across the United States.

Through an interviewee's experience with lawsuits as a practicing lawyer, they have seen that it is much more difficult for plaintiffs to make and win a case due to the loopholes with the guidelines of these standards. Moreover, since the US Access Board has no communication with lawsuits, the results of cases do not effectively streamline into the development of new standards or in improving unclear clauses. Hence, many complaints and lawsuits are not taken into consideration as they are more difficult to defend from a legal standpoint despite the existence and support of governing standards and legislation (Personal Communication, March 24, 2021). This direct perspective highlights the underlying issues with the standard enforcement and the gaps in the process of communication.

Additionally, there are several issues that arise when dealing with the enforcement of these federal laws and regulations. One of the most important issues reveals that the federal laws, such as the ADA, have imprecise definitions of terms that often lead to the under-enforcement of federal accommodation law in cases of discrimination against people with disabilities. The enforcement of several standards ultimately depends on how the courts define "disability" and

"reasonable accommodations." There is no one clear, precise definition for either of these terms since each person, company, or court will take on a different definition (Gould, 2004). This has resulted in several lawsuits started by both people with a tenuous claim to a disability with a tenuous claim to unreasonable accommodations and people with a clear, objective disability with a strong claim to unreasonable accommodations. Of these several lawsuits, a great number of them focused on the accessibility of SSTs for people with varying disabilities. The lack of precision of these standards has played a major role in allowing frivolous lawsuits to obscure justice for truly meritorious lawsuits (Gould, 2004).

To counteract the growing pains and lawsuits, George W. Bush signed the Americans with Disabilities Amendment Act of 2008. This modified act was established to provide more protection to individuals with a disability under a broader interpretation of the term "disability" (*The Americans with Disabilities Act Amendments Act of 2008 | U.S. Equal Employment Opportunity Commission*, n.d.). Not only did this amendment allow more people to be protected by the ADA, but it also provided the federal government agencies with more enforcement power. The agencies can be stricter with their enforcement and ensure that companies and public services are not discriminating against qualified individuals with disabilities. Although updates and amendments can be made to federal laws and regulations, gaps still remain in how these disability legislation and SST accessibility standards are enforced by federal agencies and obeyed by companies.

Conclusion

Beginning in 1968 with the passage of The Architectural Barriers Act (ABA), federal legislation first started addressing the unmet needs of people with disabilities. As with the passage of much federal legislation, however, the implementation of its directives was not always straightforward, and its coverage of the intended population was not always comprehensive. Additional legislation including the Rehabilitation Act of 1973 and the Americans with Disabilities Act of 1990 expanded the scope of protections and added additional mechanisms for the generation of standards and the enforcement of the aforementioned standards. The US Access Board is one of the major resultant bodies that sprouted out of such legislation and is an independent body tasked with developing standards, aggregating complaints, and addressing compliance. At present, however, litigation of disability law persists primarily due to nebulosity regarding both the definitions of disability and of reasonable accommodation.

With the onset of federal and subsequent state disability law, both private and public entities began to adjust their business practices and technologies to both actively incorporate non-discriminatory practices and avoid litigation risk. Specifically, self-service technologies such as gas stations, drive-thrus, ATMs, and voting booths have evolved as technology has advanced and accommodated for various populations, including those with disabilities. However, recent advancements, such as late-night food services, are typically drive-thru only and fail to consider those with disabilities; and ATMs are still not very accessible for those who are visually impaired. On the other hand, the recent shift towards mail-in voting and away from the traditional voting process can benefit people with mobility challenges. Though there are many obstacles facing people with mobile and cognitive disabilities, these challenges are yet to evolve into efficient solutions that accommodate both people with a range of disabilities and those without. Current standards have clearly outlined ways to address these problems, but the issue remains that each disability is unique as are the challenges to overcome. With new knowledge and technological advancement, progress can be made with clearly much room for improvement.

Chapter 3: Smartphone Interaction with Self-Service Technology

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Smartphone-Self-Service Technology Interactions for Individuals with Disabilities

Disabilities and Smartphone Use

Smartphones are widely accessible to individuals with disabilities. As of 2016, 72 percent of people with disabilities owned smartphones (Morris, Sweatman, & Jones, 2017). This figure had increased from 57 percent in 2013 (Morris, Sweatman, & Jones, 2017), and has likely increased since 2016. Of these users, 81 percent used the internet regularly and 70 percent used mobile apps regularly with their smartphones (Morris, Sweatman, & Jones, 2017). Hence, a large percentage of individuals with disabilities already use smartphones in their daily lives, which signifies that smartphones could help improve accessibility in other applications.

Almost all smartphones are considered Apple or Android devices. Both Apple and Android devices offer accessibility features that increase ease of use for individuals of differing disabilities. For example, Apple provides features that can assist users with disabilities, such as voice control, dictation, and switch control (Apple, 2021). Voice control and dictation functions allow users to perform almost all smartphone functions with their voice (Apple, 2021). Switch control allows users to control their device with external hardware (Apple, 2021). Androids offer other features, such as live transcribe, sound amplifier, talkback, and lookout (Android, 2021). Live transcribe and sound amplifier are designed for individuals with hearing disabilities. Live transcribe creates a real-time caption of a conversation, and sound amplifier increases sound and filters out background noises (Android, 2021). Talkback and lookout features are designed for users with visual disabilities. Talkback allows users to listen to everything that is displayed on the screen and lookout utilizes the camera to identify and tell users what they are looking at (Android, 2021). In conclusion, smartphones offer specialized features that increase accessibility to users with disabilities.

In a recent survey on individuals with disabilities conducted by the authors of this report, 22 of 24 respondents indicated that they are somewhat or extremely comfortable using smartphones and use them for at least 2-5 hours or more during the day. Furthermore, at least half of the respondents indicated that they would use a smartphone-SST interaction with ATMs, kiosks, payments at storefronts, or at drive-thrus (2021). This shows that a smartphone-SST interaction can be a viable way to make self-service technologies more accessible to individuals with disabilities. One top concern of these smartphone users is that accessibility in apps developed without using the native operating system are harder to learn and control. According to an interview with an experienced app developer, built-in accessibility features are available when an app is developed on the operating system, such as iOS or Android (Personal Communication, April 19, 2021). Therefore, in order to include features that make smartphones more accessible, the SST-smartphone interaction will have to be developed using the phone's native accessibility functions rather than another system.

A smartphone-SST interaction would benefit individuals with disabilities in various self-service settings by allowing a customizable approach. Integrating a smartphone interaction with self-service technology would allow users to use technology they are comfortable with during SST operation, ultimately increasing accessibility and independence.

Current Technologies

Current smartphone-SST interactions include contactless payments, such as Google Pay and Apple Wallet. These technologies allow users to use their smartphones to make secure, contactless payments at stores using an app on their phone. The smartphone-SST interaction is completed through a near field communication reader present in the payment terminal and radio frequency identification technology in the smartphone (Kagan, 2020). This is the same technology as "tap" credit cards (Kagan, 2020). This smartphone-SST interaction requires an app interface on the smartphone and a near-field communication (NFC) reader on the self-service technology device.

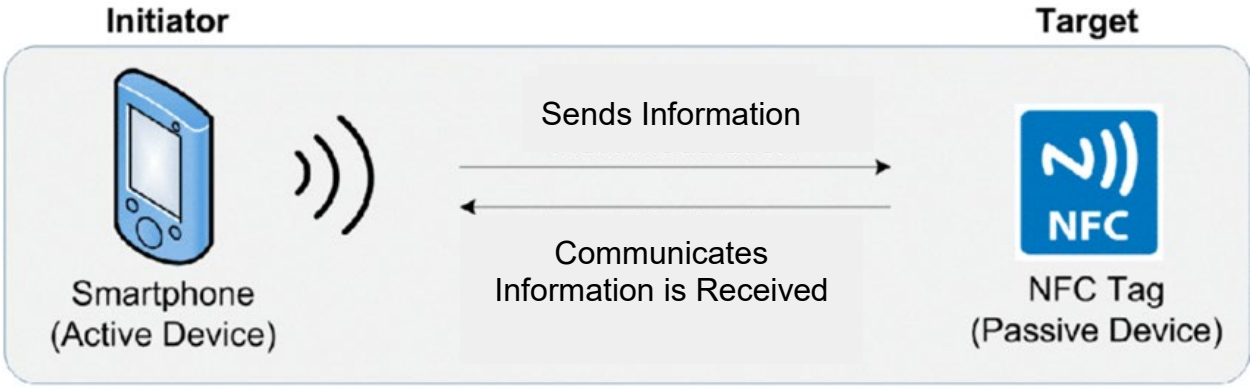

Figure 3.1: How Smartphones and NFC Readers Communicate (Coskun, 2015)

Another example of smartphone-SST interactions is scanning a Quick Response (QR) code, which is a two-dimensional bar code that brings up a website or interaction ("QR Codes 101: A Beginner's Guide", 2020). A special app is required on some phones to scan QR codes, but newer smartphones have QR scanners built into their cameras ("QR Codes 101: A Beginner's Guide", 2020). One of the main benefits of QR codes is that they are free to make and therefore a cost effective interaction (Unitag NFC, 2012).

There are some disadvantages with QR codes, however. For example, QR codes are easy to replicate, which could cause security concerns, especially with sensitive information like credit card or bank account numbers (Unitag NFC, 2012). In a recent survey conducted by the authors of this report, security of the smartphone-SST interaction was a concern for 42% of individuals with disabilities surveyed, making it the top concern. According to an experienced app developer, NFC is a more secure technology because the information being sent uses a one-time code for the NFC reader to access information (Personal Communication, April 19, 2021). Therefore, the information approved by the user is sent, then the code is changed and there cannot be any repetitive security attacks on the device (Personal Communication, April 19, 2021). Another issue with QR codes is that they may not be the most accessible to individuals with disabilities. According to a special education professor who developed an app for individuals with autism, QR codes are also difficult for some individuals to manipulate (Personal Communication, April 12, 2021). Capturing a QR code requires a level of precision that some individuals may not be able to accomplish because of a disability that impacts fine motor skills (Personal Communication, April 12, 2021). The experienced app developer believes that an NFC-smartphone interaction would be more advantageous for individuals with disabilities because NFC is based on proximity (Personal Communication, April 19, 2021). This proximity can be up to 10 cm, but the specific distance is programmed into the kiosk (Unitag NFC, 2012).

Therefore, the individual has more flexibility in where they can put their device. Another option would be low energy Bluetooth, which can have a proximity of up to 50 feet (Unitag NFC, 2012). In this case, the individual would not have to scan anything or put their device in a specific position to interact with the kiosk as long as they are nearby (Personal Communication, April 19, 2021).

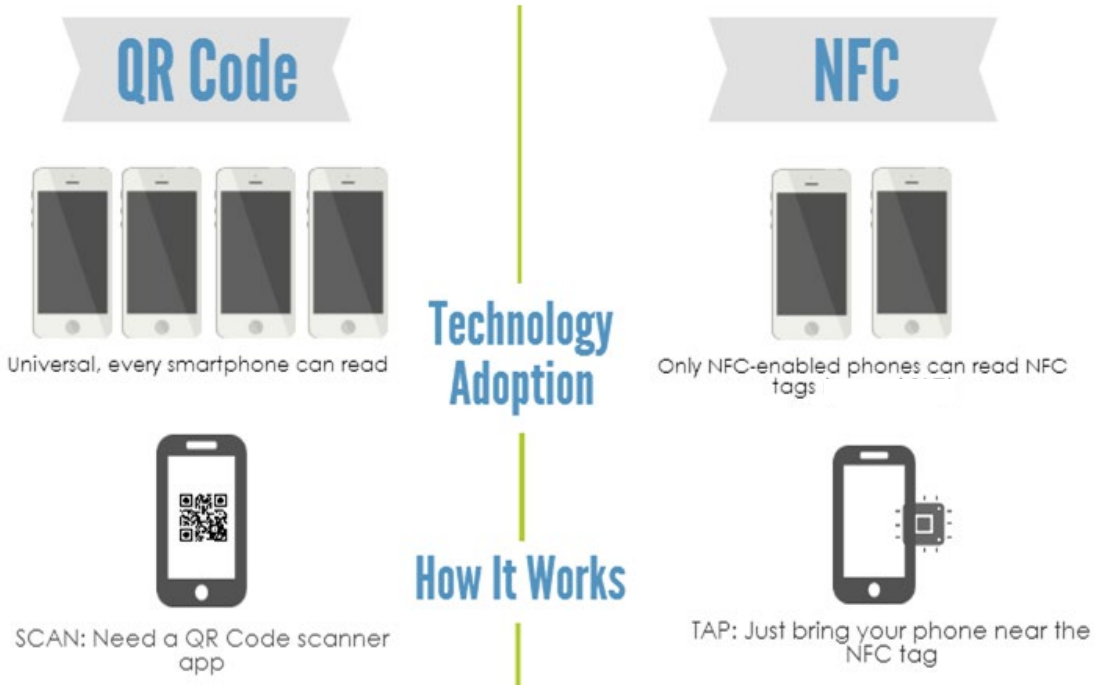

Figure 3.2: QR Code Versus NFC (Unitag NFC, 2012)

Potential Improvements and Future Designs

One of the approaches to giving a user access to some features on an SST that their disability prevents them from easily accessing, involves having an attendant give assistance. Due to limitations this causes, only certain actions are possible at various SSTs. For example, a blind person can get their money out of an ATM, but cannot check on their account balance or access various other features that would normally be available (Personal Communication, April 5, 2021). This is largely because of privacy concerns. Some of the information that would normally be provided is too sensitive to be read out loud, such that anyone nearby could hear it. Also, an on-duty attendant cannot always be trusted with this information either, which leaves few options available to blind users. A blind Purdue faculty member expressed in an interview that they rarely use point-of-sale devices, such as credit/debit card readers and NFC readers, since these devices rarely have text-to-speech software (Personal Communication, April 5, 2021). Other parts of some kiosks, like grocery store self-service checkouts, are accessible, but the payment portion remains inaccessible. Furthermore, they avoid solely touchscreen-based kiosks since they cannot see or feel where they need to press, regardless of whether the kiosk has text-to-speech or screen reader functionality (Personal Communication, April 5, 2021). One potential improvement here is to utilize built-in audio jacks on ATMs and other SSTs to allow users to have sensitive information read to them through the use of screen readers without it compromising the security of that information. In an interview with a special education professor, they expressed that it would be beneficial for SSTs to have the ability to automatically

connect to audio devices that are connected to the user's phone (Personal Communication, April 5, 2021). This could be done by allowing Bluetooth or NFC compatibility between SSTs and smartphones. In the same interview, the interviewee explained that many people with visual disabilities are already very familiar with Bluetooth technology because it is used with many braille displays and wireless headsets already (Personal Communication, April 5, 2021). Alongside Bluetooth technology, another potential improvement for SSTs is to allow users to create settings on their smartphones which could be automatically recognized by an SST. This would instantly adapt the settings on the SST to include all necessary accessibility features that the user set up. Some potential accessibility settings which could be preset include zoom level, color scheme, light/dark mode, automatic screen reading, and other features. This type of improvement is especially appealing because it does not present a security risk since this information is not sensitive.

Experienced app developers at Purdue created an app which would cross reference images the user takes with their phone with data in its system to then give the user information on what they took a picture of (Personal Communication, April 19, 2021). This could potentially be used with SSTs by allowing the user to take a picture of an SST with their smartphone and then giving the user all available information on what accessibility options are available on that SST. There is also smartphone technology in development for tracking the user's attention and eye movement (Personal Communication, April 19, 2021). This newer technology can be used in tandem with a screen reader that can specifically read out or otherwise describe whichever part of the SST that the user is looking at. As app development technology has advanced, more accessibility options have been steadily made available for free to developers according to an app development expert at Purdue (Personal Communication, April 19, 2021). Because of this, it is increasingly likely that more of these potential improvements and future designs will be eventually implemented into future SST designs.

Applications of Smartphone Use with SSTs

The benefits of utilizing smartphones with SSTs are apparent in many applications. In the food industry, there is mobile ordering and contactless payment, which allows individuals with disabilities to order food from a menu that is clear to them using custom accessibility features like enlarged text, text to speech, Bluetooth add-on devices, or even ordering via voice commands. These methods are much easier for people with disabilities to use because they do not have to struggle with any of the following: manipulating inaccessible ordering kiosks, reading a menu posted at a distance, having difficulty communicating with a cashier, physically handling cash or a credit card, or waiting in a line at the register. These individuals already know how to use their smartphones the way they want to, which would allow them to ensure accuracy of their order, and then they do not need to learn a new kiosk system. A 2014 study done by Gelbrich & Sattler suggests that public self-service kiosks may not be readily adopted because the expectation of faster service creates anxiety for users about perceived time pressure and impatient crowds. With smartphone-enabled self-service, these anxieties may disappear, as the user is allowed to complete the transaction in a private space and progress at their own pace. Restaurants, fast food places, and even hotels can be notified in advance if the person coming in with a mobile order or a reservation requires assistance. In the transportation industries, ticket kiosks can now be accessed or bypassed by digital tickets and passes bought online through accessible websites. In banking, the transfer of money between accounts or people can be done digitally, bypassing the need to count money or manually type credit card information into a kiosk or ATM, which protects the user from theft.

Potential Drawbacks of a Smartphone-SST Interaction

Risks of Smartphone and SST Use

There are many risks involved with using smartphones with SST including rate of errors, inability to solve complex issues and a combination of security and privacy concerns. Starting with the security and privacy concerns, mobile devices were designed for convenience and portability rather than security. Smartphones do not have the same level of security as computers since most of them do not include firewalls and connect to the internet using unsecured public networks or cellular data (PCI Compliance, 2017). This opens up the possibility of malware to intercept extremely integral data such as credit card data, bank information, financial management information, and others. Not only are smartphones susceptible to security risks, but the kiosks themselves are also able to be hacked or modified with third party hardware. The reason kiosks are vulnerable is because of the actual physical configuration of the kiosk, because of devices like skimmers or fake keyboards. This vulnerability stems from many kiosks being available to anyone in the public at all times and some of those kiosks not being properly monitored during all hours of availability. Once a kiosk is hacked or tampered with, this allows malware to interact with a smartphone and get unwanted access to documents mentioned above and more (Maras, 2019).

A recent survey conducted by the authors of this report showed that 37% of self-service technologies are those at ATMs and payment or credit card related transactions. Furthermore, 42% of participants in the survey stated that their biggest concern with integrating smartphones with SSTs is privacy. This statistic emphasizes the need for improved security around SST terminals, especially with phone interactions, with the rising use of payment methods and sensitive information that is placed on smartphones.

Another concern of a smartphone-SST interaction is the current likelihood of software incompatibility and limitations. The software being used in the SST must be compatible with all types of phones, and vice versa. Incompatibility throughout smartphones leads to prevention of interaction, rendering the SST useless. Kiosks can be limited in their functions and capabilities and adding smartphone interaction can increase the complexity of the overall system. Human interaction would likely be required after a problem occurs with SST-smartphone interactions as most kiosks cannot troubleshoot themselves. In the survey of individuals with disabilities conducted by the authors of this report, several users had complex problems with kiosks. A few users experienced changes in font size and hearing when interacting with ATMs and kiosks, which prevented them from accessing the information they required. Once this problem arises, users are obliged to ask for external help which exposes them to a privacy risk from a third party, such as an attendant accessing their payment information. This same problem could occur with a smartphone-SST interaction and require attendant intervention.

Legal Concerns of Smartphone-SST Interactions

The Americans with Disabilities Act (ADA) has multiple requirements which are meant to protect Americans with disabilities. Specifically, Title III of the ADA prohibits discrimination against people with disabilities by legally requiring private entities that do business with the public to take affirmative steps to make sure that people with disabilities are given equal access to their goods and services (Vu and Sarnoff, 2017).

In 1991, the U.S. Department of Justice (DOJ) created a list of auxiliary aids and services that a public accommodation, such as a checkout station, may need to provide to ensure effective communication with an individual with a disability (Vu & Sarnoff, 2017). It was noted then that this list was not meant to apply exclusively to only the items mentioned in it, but rather use them

as an example of what should be included. The SSTs that are used today did not exist at the time this original list was made. In 2010, the DOJ expanded upon its definition of "auxiliary aids and services" by stating that this includes "accessible electronic and information technology" as well. This statement was added in order to include websites, mobile apps, and other SSTs under Title III. However, the wording was kept vague and only a few specific SSTs are explicitly stated as requiring accessibility features: ATMs, vending machines, and fuel dispensers (Vu & Sarnoff, 2017). Despite the lack of specific requirements for SSTs, ADA compliance is still enforced, such as with the 2014 lawsuit of New v. Lucky Brand Dungarees Stores. In this lawsuit, a blind plaintiff sued the stores for only having touchscreen interfaces with their point of sale (POS) devices. The retailer made the argument that the absence of specific standards for POS devices meant they did not violate any specific law. It was eventually determined by the DOJ that Mr. New's claim of discrimination under Title III of the ADA was valid. The DOJ clarified during this 2014 case that the lack of specific requirements is meant to give public accommodations more flexibility in how they comply with Title III's requirements of nondiscrimination, but not exempt them from those requirements. Most all major retailers have since taken into account many different forms of disability with the designs of their newer POS devices; as a result of the 2014 case, most of the new POS devices include a tactile keyboard for any people who are blind. Despite what appeared to be an overall push by major businesses to become more compliant with ADA nondiscrimination laws, there were always systems and public services that were excluded and so the legal cases continued to amass.

In numerous legal cases between 2015 and 2016, the lawsuits would almost always settle early without a definite court decision, and so few legal precedents were set as to what would be considered the minimal acceptable action necessary to be considered compliant. In over 300 ADA legal disputes in this time period, only one received a final court ruling to decide the case (Vu & Sarnoff, 2017). While ADA compliance is being enforced, it is still unclear exactly what actions are required at a minimum for a business to be considered compliant. For example, most places will have a public call center available during the same times that their normal services are available; these call centers provide individual assistance to people with disabilities (Vu & Sarnoff, 2017). While many places have adapted this model, it has never been legally determined in court to be a sufficient alternative. Legal questions have also been raised as to if any alternative that requires direct assistance from another person would be considered fair and equal. There is a security concern with regards to letting someone else use one's own personal information to make monetary purchases or transactions. There is also the question of empowerment; is it acceptable to refuse to give people the means they need to perform a task by themselves when others can assist?

The integration of smartphones into SSTs to allow people with disabilities to perform actions independently could potentially answer some of these questions. However, it is as of yet unclear as to if it will be legally necessary to incorporate this solution even if it is proven to be effective. The current methods being used would need to be legally proven as ineffective or otherwise more costly to the businesses using them, than the smartphone integration solution before these businesses would be willing to replace them.

Implementation of Smartphone-SST Interactions

Business Incentives and Benefits to Increasing Accessibility

Utilizing smartphones with SST can be quicker and easier to implement than current systems. As a result, incentives for businesses will outweigh the initial financial burden. The Disability and Smartphone Use section discusses how integrating and utilizing smartphone

technology alongside SST will benefit individuals with disabilities. It is important to also understand that increasing accessibility for SST is both good for the individual and the business. Increasing accessibility helps businesses because it increases the number of potential customers and revenue, it betters how the general public views the business, and it retains customers with disabilities in a viable way by increasing accessibility through technology.

When businesses update outdated technology and systems to be more inclusive to people with disabilities, they are expanding their potential customer base to a large portion of the population. According to the 2018 report "The Accessibility Advantage" by Accenture, there are "approximately 20 million individuals with disabilities in the United States, representing US$490 billion in disposable income. Globally, these figures jump to 1 billion individuals with disabilities with US$8 trillion in disposable income, making them the 3rd largest economic power in the world above Japan, Germany, and the United Kingdom" (Andersen, 2018). Disposable income is the money that is available for an individual to spend after taxes. Businesses that do not make it a priority to allow accessibility for all do not benefit from this $490 billion in disposable income. For instance, the travel and leisure industries can maximize revenues by making sure their products and services are attainable for people with disabilities. According to a 2008 study, "travelers with disabilities spend in excess of $13 billion annually on business and leisure travel" (Future Travel Experience, 2008). This is an important statistic to note when companies decide to maintain and operate SST. Another important point to note is that consumers with disabilities often spend more per trip and shop more often. A 2016 Nielsen report shows that on average, people with disabilities spend "over $1 more per trip and average 5 more trips per year" than those without a disability (Brewer et al., 2016). Based on this information, it is important for companies to recognize their ability to maximize revenues by including access for people with disabilities.

Another avenue to increase revenue through accessibility is including smartphone payment options that can eliminate several of the security concerns for individuals with disabilities. This also increases the options for users with and without disabilities. According to research from Bain & Co., mobile payment users, on average, spend "twice as much through digital channels and tend to shop more often" (Ahmad and Bertrand, 2014). Increasing the accessibility in payment options allows businesses to also benefit from other individuals that prefer these methods as well. For those businesses that are interested in offering mobile payment to all customers, it is important to understand whether or not there are financial costs that are added. When it comes to point-of-sale devices, "in most cases accepting mobile payments will cost nothing extra for merchants" (Anderson, 2019). It is necessary to note that some types of SST may require significant alterations to existing technology or manufacturing completely new technology in order to utilize mobile payments.

Companies should operate in accessible environments in order to align their business with a positive image that the public views favorably. A survey that was published by the National Business and Disability Council in 2017 shows that "66 percent of consumers will purchase goods and services from a business that features persons with disabilities in their advertising, while 78 percent will purchase goods and services from a business that takes steps to ensure easy access for individuals with disabilities at their physical locations" (Accenture, 2018). Creating easily accessible products and services and advertising these capabilities can benefit the public image of a business.

Increasing accessibility through technology also creates an easier way to retain and grow a company's customer base. In the beginning of the smartphone era, Apple began considering

some of the issues that a touch screen phone may have on their customers with visual impairments. As a result they developed "VoiceOver, the world's first gesture-based screen reader. Within weeks of launch, Apple received a special commendation from the National Federation of the Blind 'For designing the first fully accessible touchscreen interface'" (Rush et al., 2018). Apple has since been one of the preferred companies for smartphones for people with disabilities. Creating products that service everyone has allowed Apple to increase customer base and be recognized for their efforts. People with disabilities also are increasingly tech savvy. The National Telecommunications and Information Administration reports that "nearly three out of four people with some form of disability use the internet at home and at work. Such a high technology adoption rate indicates that people with disabilities are becoming more adept at using the assistive technologies" (Future Travel Experience, 2008). This statistic indicates that as companies develop more creative methods of accessibility through technology, they are likely to be accepted by the population of people with disabilities. When speaking with the manager of a local, large-chain grocery store, they described their willingness to upgrade more smartphone-SST interaction, as many people are beginning to utilize mobile wallets and other smartphone features (Personal Communication, April 9, 2020). Along with the benefit of entertaining everyday customers, this may help increase favorability with people with disabilities that prefer to use their smartphones as a secure method to pay.

Standardization of Smartphone SST Accessibility

The use of smartphones in self-service interactions has become more commonplace in recent years. With the widespread public adoption of smartphones and the clear cost and customer satisfaction benefits of successful SST implementation, it seems logical to combine the two into a faster, accessible, and personalized/customizable service. Personalization has been a major trend since the public has been increasingly invested in personal identities, pride, and minority justice (Coray, 2020). By providing customized services, companies are connecting with their clients on a more intimate level, making them feel valued. When these products and services both improve customer satisfaction and quality of life, then the product has even better chances of success. The improvement in quality of life is especially important for people with disabilities.

These new products help inform new accessibility guidelines that would help standardize accessibility interfaces into a predictable form across multiple future products. Accessibility requirements for self-service kiosks have only just begun to be defined, however, so requirements for smartphone interaction with these kiosks are virtually nonexistent. It can be assumed that these interactions would be subject to web and app accessibility guidelines, which are well defined. When discussing personal smartphone SST, the Kiosk Manufacturers Association warns that solely relying on smartphone use for accessibility compliance would be neglecting users unable to own or use personal smartphones (2021). Therefore, smartphones should be used as an optional alternative to or in conjunction with accessible kiosks that these populations can use, not as a stand-alone solution. Kiosks themselves still need to be accessible to those with impaired dexterity, for example, via larger buttons and keyboards. Furthermore, kiosks are typically made as closed systems, with no way to access functionality outside the kiosk software module. Many kiosks are created using smart devices such as smart tablets via apps that can limit functionality of the device to only allow use of certain modules or websites. The user is not allowed to use the device like a typical smart device and change accessibility settings through the device settings app. This makes including accessible options in the kiosk module even more imperative to people with disabilities, since if they are not included it would

prevent accessibility to users who know the functionality exists in the device (Glaser, 2017). Furthermore, solving accessibility compliance by solely adding staff to assist those who need help can be degrading to users who were expecting to use the kiosk independently, since that is the main purpose of using self-service (Kiosk Manufacturers Association, 2019).

One solution to the current lack of standardization and universality that is in the works is the Global Public Inclusive Infrastructure (GPII) being built by the Raising the Floor Consortium (Stephanidis & Antona, 2014, p. 511). The Raising the Floor Consortium is an international organization committed to social equality through inclusive technology (Raising the Floor, n.d.). A main goal of the Consortium is to create the GPII, a cloud-enabled computer network infrastructure that would allow any connected computer with their product, Morphic, installed - regardless of brand or operating system, including kiosks - to automatically configure accessibility settings and third-party applications upon recognizing the user who needs that functionality (Morphic, 2021). The Morphic cloud library would contain lists of possible computer and accessibility features/programs pairs, matching a user with a personalized setup based on their needs and preferences. Furthermore, these needs and preferences would be supplied via a one time confidential survey about the user, followed by an initial setup confirmation that another person could help with or take control of if needed (Morphic, 2021).

A simpler stepping stone to implement before the GPII is finished might be a localized version that, instead of using the cloud and having to search a database, utilized a smartphone app that could tell another device - like a kiosk - via local Bluetooth what settings the user wants. Settings could again be set via survey or manual choice. This could still send instructions to utilize third-party accessibility programs, or simply receive data about the accessible features of the device and set them to what the user wants, warning if certain functionalities do not exist on the device. By only transmitting specific settings instructions, this solution would avoid the security risk of transmitting more sensitive data. Furthermore, the use of Bluetooth might allow Bluetooth-connected assistive devices, such as braille displays or hearing aids, to automatically switch connection from the phone to the device being set up to use, and vice versa. A blind Purdue faculty member working in assistive technology even said in an interview that they were very familiar with using Bluetooth assistive devices, suggesting that people with disabilities use them often and could benefit from using their personal and familiar device to interface with previously unknown system controls, such as that of a touchscreen without raised buttons (Personal Communication, April 5, 2021). They also proposed the idea that Bluetooth beacons could be used to direct blind individuals to the kiosk inside spread out buildings, such as airports, in which they describe the kiosks as being like lone islands in the middle of large empty space (Personal Communication, April 5, 2021).

Burdens to Implementation of Smartphone SST

Implementing smartphone use in conjunction with current SST systems will require several costs and adjustments from businesses, developers, and manufacturers. Manufacturing kiosk parts and updating current software will increase costs at first. Along with developing new parts and apps, many of the current systems, kiosks, and SST would have to be updated or replaced to make them compatible with the new system and smartphone technology. In an interview with a local company that provides vending machine SST, they stated that “manufacturers update their card readers in new products, but not to existing units. Software updates occur, but new technology such as touch screens or product display screens would require new unit purchases" (Personal Communication, March 30, 2021). The company stated that it is unlikely that existing vending machine units can be updated with smartphone

technology, however it is still possible that some other SST may be updated without purchasing completely new total units. When discussing some of the issues that can occur with the new smartphone wallet technologies, the same vending services company stated the following: “Software updates are based on the manufacturer's schedule, which is just whenever an update is created. [Smartphone] readers are not repaired but replaced. Wire harnesses or antennas may be replaced if needed” (Personal Communication, March 30, 2021). The smartphone processing equipment comes in modular pieces that can be replaced as needed. In order to use card tap features and smartphone pay options such as Apple Pay, SST must utilize NFC reader technology. Several companies already produce payment reader options that utilize this technology in vending machines and other SST systems. One such company, Nayax, charges around $300 for each payment reader (A&M Vending Machines, 2021). These modular pieces can be built into new and sometimes existing SST.

Another cost that may be associated with having a SST with smartphone technology is the requirement for different technology connections. The local Indiana vending service organization states that “because the readers require cell phone or Wi-Fi access and credit card processing, the vendor is charged a monthly fee on each unit in service” (Personal Communication, March 30, 2021). Updating SST to incorporate smartphone technology access may require monthly service charges depending on the vendor and the manufacturer, which would be an extra financial burden to the machine owner.

Chapter 4: Measuring the Success of Accessibility in Self-Service Technology

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Introduction

In an effort to improve self-service technology (SST) accessibility for people with disabilities, success guidelines must be determined. Measuring success and accessibility of these technologies should accommodate all disabilities and have quantifiable metrics. The authors of this report conducted literature and personal research then created a method for quantifying success of SSTs. Understanding the success of assistive technologies stemmed from discussions with individuals with disabilities as well as stakeholders. First, the key factors people with disabilities look for in SSTs were identified. This portion highlights the common hardships people with disabilities experience when using SSTs, and what modifications they may prefer in the future. Then feedback from the target population, individuals with disabilities that utilize SSTs, was analyzed. This phase included people with various disabilities and multiple demographics for a holistic view of SST accessibility and hardships. Stakeholders and the methods these individuals implement assistive technologies was then researched. This created the opportunity to reflect upon the companies that are manufacturing more accessible technology and the components they find most important in improving their technologies. After stakeholders were identified, the balance of happiness of the SST user and the business owners was analyzed. This cannot be a complete balance, as business owners should always take the necessary steps to make accessibility possible for people with disabilities. However, identifying how businesses can benefit from improving their SSTs makes these owners more likely to implement the most accessible technology on the market despite the expense. Finally, the shortcomings of old assistive technologies were recognized. Identifying these pitfalls leaves specific points of improvement for new SSTs. Overall, SSTs must be accessible to all individuals and measuring success is necessary to improve future technologies.

The Factors of Success

People with disabilities often look for a few key factors in SST that make them more successful than other products. People with disabilities face many hardships on a daily basis. The SSTs that they interact with require certain factors and qualities to be the most helpful. There are many barriers for people with disabilities to overcome, but the technologies meant to help them should consider their needs and the hurdles they deal with every day. Some of the most common barriers they face include communication, physical, policy, programmatic, social and transportation barriers (U.S. Department, 2020). These barriers are mostly related to a lack of assistive technology or technology that does not adequately address the difficulty that people with disabilities have.

In general, many customers with and without disabilities choose SSTs like ATMs or kiosks because of their availability, speed, and reliability. SSTs are often readily available and therefore much faster than alternatives. The service is also consistent and more reliable than interacting with a person. While all of these factors are also appealing for people with disabilities, they are not the most important factors that people with disabilities look for.

While speed, availability and reliability are attractive factors, accessibility of these SSTs is paramount for people with disabilities. Specifically, physical accessibility is most important for those in wheelchairs or with other physical impairments. There has to be enough physical room as well as an appropriate height of the screen or buttons to allow for full access to the machine. SSTs can also present an issue for people with visual impairments because they cannot see the screen and the braille on the buttons can be too small. Many kiosks also "time out" after an allotted amount of time, which presents an issue for people with cognitive disabilities.

Another important factor that makes SSTs more available for people with disabilities is the ease of use. The technologies should be easy to understand and use for everyone. The devices should allow anyone that uses them to do so in a reasonable amount of time comparable to or quicker than that of a business without these technologies. People with disabilities should be able to use them without any help. Many individuals also prefer that they are compatible with smartphones or devices that they are used to utilizing. SSTs that are mobile device-friendly are often preferred to those that are not smartphone adaptable (Mare, 2019) (see Chapter 3).

The authors of this report conducted interviews and surveys with the target population and the feedback agreed that ease of use and time of use were the two most important factors for people with disabilities. Based on the responses, privacy is also another factor that can improve SSTs for people with disabilities. Some common responses to the survey indicate that SSTs should include buttons with braille, larger text, and screens that are adjustable in height and tilt. More than 60% of people with disabilities we surveyed actually preferred using SSTs over being assisted by a human. These technologies are helpful, but need improvements in order to best address the concerns of people with disabilities. The factors of speed, availability, reliability, physical accessibility, privacy, time of use, and ease of use described here are all categories that should be used to quantify the success of SSTs.

Quantifying Success

In an effort to obtain current and unbiased feedback on SST accessibility, numerous responses from our target population were recorded through interviews and surveys. Initially, participants are asked to provide their age, gender and a brief description of their disability. This allows interviewees to remain anonymous while still providing researchers with sufficient information for analysis. Next, participants were asked about their personal experiences with various SSTs, their shortcomings, and any improvements they would like to see made. Participants were also asked several questions about the integration of smartphone technology into SSTs, as this has been hypothesized to be a source of major accessibility improvement in the near future.

After receiving feedback from our target population, responses were analyzed to identify commonalities. These trends are indicative of the areas where SST accessibility has the most room for improvement. Alternatively, these trends can also indicate areas where SST accessibility is currently sufficient, or sufficient enough to not be a focus of this study. Assuming a sufficient number of responses are collected, it is expected that individuals with different disabilities will place an emphasis on different factors of SST accessibility. For example, a person in a wheelchair might place more emphasis on the physical accessibility or availability of an SST, whereas someone with a visual impairment might place more emphasis on privacy. To analyze results with this in mind, responses can be stratified by the category of disability specified by the interviewee (mobility, visual, hearing etc.). Evaluation of trends within each stratum will prevent responses from being overlooked due to a small number of participants from that stratum. For example, if the feedback received from a small number of people with hearing

disabilities deviates from the majority of feedback received, it might be overlooked. However, if this deviation was common amongst people with hearing disabilities, it likely indicates an important factor of SST accessibility for this group. This would also suggest that more feedback should be collected from this stratum in regard to the deviation and provide an opportunity for a follow-up study.

In an effort to draw more concrete conclusions from our feedback, several questions accept numerical responses. Specifically, survey questions ask the participant to rank several factors of SST accessibility on a scale of 1-5, with 1 being the worst and 5 being the best. These factors include ease of use, self-sufficiency, time of use, privacy and availability. A One-Way ANOVA test was performed on these responses to determine which factors showed the most room for improvement (Jokisuu et al., 2015). Participants were also asked to rank these factors against each other from most important to least important. A pairwise Friedman's ANOVA was chosen to evaluate these responses as the data is ordinal (Riffenburgh et al., 2006). A summary of survey and interview responses to these questions can be seen below in Tables 4.1 and 4.2. The data in these tables is reflective of the surveys conducted by this research group.

When interpreting a large amount of feedback, different elements of that feedback can carry different weights, depending on the goal of the research. Given that there is a forward-looking aspect of this paper, elements of feedback that contribute to potential solutions or improvements for SST accessibility will be prioritized. However, current shortcomings must be identified in order to propose relevant solutions. Furthermore, given that this paper is aiming to draw conclusions based on responses from the target population, no weights will be placed on any specific elements of accessibility. This avoids the risk of prematurely placing emphasis on an element that the target population does not actually value.

Table 4.1 (Survey, April 12, 2021): Participants' Rankings of Importance of SST Design Factors (1 = Most Important to 5 = Least Important)

Factor	Min	Max	Mean	Count
Ease of use	1	3	1.46	24
Self-sufficiency	1	4	2.21	24
Time of use	1	5	3.83	24
Privacy	2	5	4.17	24
Availability	1	5	3.33	24

Table 4.2 (Survey, April 12, 2021): Participants' Satisfaction with SST Factors (1 = Extremely Dissatisfied to 5 = Extremely Satisfied)

Factor	Min	Max	Mean	Count
Ease of use	2	5	3.26	27
Self-sufficiency	1	5	2.92	26
Time of use	1	5	2.56	27
Privacy	1	5	2.74	27
Availability	1	5	2.42	26

As seen below in Table 4.3, post-hoc p-values of all possible pairs are compared using a triangular matrix. Each number in the table is the p-value for the associated row/column pair. At a significance level of 0.05 it can be seen that all pairs are significantly different. Therefore, we can conclude that our target population ranks the importance of these factors of SST accessibility from most important to least as follows: ease of use, self-sufficiency, availability, time of use and privacy. Table 4.4 below summarizes the results of the One-way ANOVA. With a p-value of 0.077, we can conclude that there were no significant differences between satisfaction levels with any of the five factors. Based on this evaluation, future improvements to SST's should primarily consider ease of use and self-sufficiency to best assist customers with various disabilities.

Table 4.3: Friedman's ANOVA Results of Table 4.1 Data

	Ease of Use	Self-sufficiency	Time of use	Privacy
Self-sufficiency	6.634e-9			
Time of use	2.051e-42	1.553e-32		
Privacy	1.458e-48	5.15e-40	5.811e-6	
Availability	2.82e-32	4.372e-20	4.117e-9	5.352e-19

Table 4.4: One-Way ANOVA of Table 4.2 Data

Source	Sum of Squares	Degrees of Freedom	Mean Square	F Statistic	p-value
Treatment	11.447	4	2.862	2.165	0.077
Error	169.229	128	1.322		
Total	180.677	132			

It is worth noting that the sentiment of our target population is likely to change over time, as different types of improvements are made to various SSTs. Also, the lower number of survey

and interview responses in this study indicate how difficult it can be to receive feedback on these issues. Because of this, it is necessary that a consistent way to receive feedback from our target population is set in place. This could be as simple as integrating a quick survey question into various SSTs or partnering with organizations that have a large outreach. By frequently completing this type of analysis, more concentrated efforts can be made to improve SST accessibility and to prepare guidelines of success.

Identifying the Stakeholders

The next thing to consider would be the many stakeholders involved in SSTs that contribute to the creation of the technology as well as ownership of the devices. The SST industry is quickly growing every year and the stakeholders that help in creating these devices include network service providers, component manufacturers, hardware providers, system integrators, and deployers. These are general categories of stakeholders as there are different companies that fulfill these roles such as Cennox, Neonode, TES America, and many more (Shende, 2015). It is important to mention these stakeholders as they help create the product and are the ones working on making newer technologies more accessible to a wide variety of disabilities. It is also important to note that competition between these companies drives them to create better SSTs that are more accessible as well as preventing the industry from getting monopolized. These stakeholders are primarily based in the Asia Pacific geographical market but also are located in different locations such as Europe and North America.

There are also stakeholders that are more directly involved in the use and purchasing of SSTs. These stakeholders include business owners, customers with disabilities, and customers without disabilities (Shende, 2015). Business owners are essential stakeholders as they implement these technologies into their businesses to create a more accessible environment for the customer. The business owner buys and maintains SSTs as needed. Customers with disabilities are the targeted customer for these technologies as they are the ones that benefit the most from the increased accessibility. The creation of new and more accessible technologies is driven by this specific stakeholder. It is also important to mention the use of these technologies of customers without disabilities as this stakeholder is likely a common user of these technologies without utilization of the accessibility features as it can commonly be a quicker way to use a service such as an ATM.

Beyond the stakeholders, it is important to discuss how businesses can implement the technology and how it can be successful for users with disabilities. In a study of 22 suppliers and distributors of SSTs there were three themes found that affect how well businesses can implement the technology and how to make it successful (Petrie, 2014). The first theme was that many suppliers have very limited knowledge about the need for accessibility beyond the requirements for physical disabilities especially for those with visual and hearing disabilities. The second theme to emerge was the perceived cost of these accessible technologies by business owners. The common issue was business owners did not believe there was enough of a return on the investment of buying SSTs as well as lack of resources. The final theme that emerged was the need for clear guidelines on creating SSTs that were accessible as many companies that create the SSTs did not know how to solve accessibility issues (Petrie, 2014).

There were also recommendations made by the study on aspects that needed to be improved for SSTs to be more accessible and successful. The first recommendation was for businesses to be more in contact with suppliers of the industry to create better products and address disabilities that are being ignored. The second recommendation was to collect more information about current problems with SSTs and to have this be passed on to relevant

stakeholders to also create better products. The third recommendation was to raise the level of awareness from simply physical accessibility to include other disabilities as well such as visual and hearing disabilities. This is needed to appeal to stakeholders that are not benefiting from the current technologies and need better technology to be better able to use these SSTs. The final recommendation was to change the perception of SSTs to business owners as it would be very beneficial to most businesses and that it would help many people use their service (Petrie, 2014).

Business Owner's Happiness vs. Consumer Happiness

When considering the quantification of success in SST accessibility, it is also important to view the issues from the views of all stakeholders. One factor that cannot be overlooked is the balance of creating an accessible environment for people with disabilities while not causing an unnecessary burden on business owners. This trade off will never be completely equal between all parties due to its nature, however attempting to find a balance that all sides are happy with must be a priority.

Ensuring ADA compliance in businesses has long been an issue. While in an ideal world business would want to be accessible to people with disabilities out of compassion, this is not always the case. Many business owners push ADA compliance to the wayside. To provide an incentive to these businesses to be ADA compliant, the IRS has offered tax breaks for businesses with under 30 employees. Without this incentive, businesses would be less inclined to meet the standards required by the ADA.

Another facet of this issue is the ethical dilemma of accessibility compliance. One question that can be brought up is whether or not businesses should be required to create accessible SSTs in a private business. Some business owners contend that implementing accessible kiosks should only be done at their own prerogative and that it is not the government's place to require it. These people believe that it is their right to do business as they wish to and if that means they lose out on some business; they are willing to take the loss. On the other side, some people contend that handicap accessibility is a right and that the right should be protected by the government. These individuals believe in equal access for people of all ability levels. The United States Department of Justice has defined accessibility as a civil right (EDUCASE, 2016). This means that businesses and other establishments are required by law to conform to defined standards. While this may seem like an answer to the issue of businesses not creating options for accessible SSTs, there are many loopholes and ways to get around conformity. These laws are also extremely difficult to enforce. This has led to many business owners viewing these compliance laws as suggestions rather than requirements.

Businesses are faced with a decision in regard to accessible kiosks. The first option is to spend money upfront to implement technology and measures to ensure compliance with the ADA. This option prevents any fines or legal action before it has a chance to occur. This is the safest option for business owners as it will guarantee that they will not have an issue with the ADA. This option can also lead to an increase in customers with disabilities due to the infrastructure and technology available to the customers. However, it can be expensive to install these SSTs and kiosks which can cause apprehension from business owners. This leads to another option for businesses. Businesses can continue to operate without conforming to the guidelines and risk, facing penalties if there is a complaint. This option can be appealing to businesses as they will not have to spend money on new kiosks and SSTs. However, there are many legal repercussions if they are caught. Businesses caught in nonconformity can face fines as high as $92,000 for a first offense (ADA). Hence, when defining the success of SSTs the

interests of businesses must be taken into consideration. Therefore, the incentives of installing accessible SSTs should be clearly understood to improve access for PWDs.

Learning from Old Technology Pitfalls

The final thing to consider is how old technologies are not meeting the standards of success and how newer technologies should learn from these pitfalls. To understand how technologies have been improving, current technologies can be compared to those of the past. Factors that feed into these improvements include manufacturing cost, innovative design, demand for assistive technology, as well as new laws and regulations that ensure the needs of people with disabilities are met.

Businesses are now faced with increasing demand for accessibility for those with a disability. It has become not only an ethical issue that must be addressed but is also now a financial concern. This standard of success stems from the feedback received from our survey of the target population. These include: ease of use, self-sufficiency, privacy, accessibility, and time of use. Based on the feedback, it is clear that many key factors of accessibility have failed to be addressed in old technologies. This is in part to the failure to understand the needs of the population and possible resistance from businesses to implement new technology.

Generally, it is agreed upon that SSTs have improved greatly over the years and that the new systems are designed with more in mind. The main two challenges that groups in charge of these systems face include the functionality of the device as well as the overall cost of implementation. While great strides have been taken to improve SST accessibility, feedback from the target population has indicated that current SSTs fail to meet the needs of individuals with disabilities. Moving forward, a greater understanding of the population's needs as well as lowering the cost of manufacturing could address many of the pitfalls seen in old SSTs. When designing new technology, understanding why previous models failed always shows the greatest space for improvement.

Conclusion

The metrics of success identified in this section provide a holistic view of accessibility issues and a guide of what improvements could be made in future SSTs. The target population was identified to be people with disabilities who commonly use assistive technologies. Survey and interview responses from this group offered the opportunity to quantify feedback received regarding demographics, important aspects of SSTs, and accessibility issues through statistical analysis. Important factors for SST success include availability, speed, reliability, ease of use, and accommodation for all types of disabilities (physical, visual, cognitive, etc.). The feedback received identified ease of use and self-sufficiency as the most important design factors of assistive technologies. The stakeholders were recognized as individuals and businesses who work to create the SSTs. Communication should be opened between SST suppliers, businesses and individuals with disabilities in order to create the best possible technology. Increasing awareness and information intake would also improve the success of these technologies. Moving forward, the happiness of the businesses and business owners must also be accounted for. Currently, businesses either spend money to implement ADA compliant technologies or risk being penalized in the future if ADA specifications are not met. Making accessibility possible is the priority, but if business owners are reminded of the benefits associated with implementing new SST technology they are more likely to find the best accessibility options on the market. The final aspect of technological success is identifying the pitfalls of previous technologies. Pin-pointing the shortcomings of old SST technology create an opportunity for improvement in new

accessibility options. Overall, understanding the target population, stakeholders, factors of accessibility, business standings, and past technology shortcomings identifies success from various perspectives. If these metrics of success are recognized, future SSTs will provide a more accessible environment for people with disabilities.

Chapter 5: Foreseeable Game Changing Solutions for Self Service Stations

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Introduction and Statistics

In a world that is rapidly moving away from human service and toward automated self-service technologies, such as gas stations, vending machines, hospital check in kiosks, and many more, millions of people are being left behind. SSTs are not always designed with accessibility requirements in mind. 19% of the USA's population has a disability; therefore, SSTs need to be designed or modified to allow for equal use opportunity. Most kiosks were not designed for use by the visually impaired, although there are 8.1 million people in the United States with impaired vision, including 2 million people who are blind. SSTs can also be limited by hearing ability. In the United States, 7.6 million people are hearing impaired. SSTs also need to be designed with accessibility for users who have impaired mobility. 19.9 million people in the United States have difficulties lifting, grasping, and/or pressing buttons (NCR).This chapter covers the current problems in the accessibility of various SSTs and how implementing intuitive features and creating universal designs will improve access for all. This chapter will also delve into future, cutting-edge technologies that could change these issues with accessibility going forward.

Accessibility of Current Self-Service Technologies

50% of respondents to our survey reported that they are either somewhat dissatisfied or extremely dissatisfied with the ease of use of self-service technologies (SSTs) and 43% were somewhat dissatisfied or extremely dissatisfied with the self-sufficiency of SSTs. There are obvious issues with the accessibility of various SSTs; therefore, implementing intuitive features into the SSTs will promote greater use for people with disabilities.

Touch Screens

The use of touch screen technology has grown quickly in recent years and is only expected to grow faster as the touch screen technology market was at $8.47 billion in 2018 and is projected to reach around $22.3 billion by 2025 (Zion Market Research, 2019). With the adoption of new touch screens, older methods, such as touch pads with braille markers or human assistance, are being phased out, and along with that a whole group of users is being excluded due to the inaccessibility of touch screens to some individuals with disabilities.

The first user group that is being excluded are individuals with visual impairments. One main issue with touch screen technology is the lack of tactile or haptic feedback to the user. Traditional ATMs contain a physical number pad with raised markings on the numbers, however such sensory information is not available on a touch screen. Therefore, a new way of inputting information on a touch screen is needed. Jokisuu et al performed a usability study on the various gestures for inputting information on a touch screen for users who are visually impaired. This study considered various gestures for selecting or typing things on an ATM style touch screen including multiple taps, striking tally marks, tap and hold gestures, or tactile strips at the bottom of the screen to help guide the user. Though the tactile strips, which resemble the traditional

ATM pad, were rated the highest in accuracy and comfort, other methods showed promise, especially when there was auditory feedback involved (Jokisuu et al., 2016).

Figure 5.1: The traditional ATM pad and the prototype tactile strip marker for touchscreens (Jokisuu et al., 2016).

Although most remedial measures for accessible touch screens are geared toward users with visibility issues, they are not the only user group who has difficulties using touch screen technologies. Some users with physical disabilities also struggle with accurately inputting information on touch screens. Chen et al studied various combinations of button size and gap between buttons to find a combination that was useful for both individuals with motor control disabilities and those without. Results showed that a 25mm-30mm size button with a 3mm gap increased accuracy and efficiency for using the touch screen, even though a 2007 ANSI Human Factors Engineering Standard recommended a 9.5mm square button with 3.2mm gaps (Chen et al., 2013). Adequately sized buttons with well differentiated boundaries are beneficial for all users to accurately input information.

Current touch screen technology is inadequate to ensure that all users are comfortable and able to use such technology. Implementing tactile, haptic, or even auditory feedback would be beneficial for promoting accessibility to users with visual impairments; and using simple and easy to understand gestures would continue to promote accessibility to other users such as those with motor control issues.

Gas Stations

With more advances in technology, more, safe modifications can be made to vehicles that allow individuals with travel-limiting disabilities to operate the vehicles. According to the US Bureau of Transportation Statistics, about 55% of working individuals with travel-limiting disabilities drive a personal vehicle, while about 43% of non-working individuals with travel-limiting disabilities drive a personal vehicle (Bureau of Transportation Statistics, 2018). In our survey regarding which SSTs would benefit the most from universal access and technology improvements, 14.7% stated gas stations, which followed ATMs and drive-throughs. 20% of the respondents of our survey reported that they would rather have human assistance while 50% said they prefer to do things on their own, with the other 30% preferring to have some interaction with both.

ADA guidelines for assistance at gas stations state that gas stations must provide equal access to the customers with disabilities through providing refueling assistance. However, when there is only one employee working, it is not feasible for this employee to leave the cash register behind. Through interviews, it has been noted that there is often only one employee at the gas

stations so receiving help refueling often does not happen, leaving the individual to do it themselves or having to leave.

Major issues that have been identified for gas pumps are tied to the space needed to fit a wheelchair between the vehicle and pump, and the reachability of the buttons on the pump. The minimum space needed to fit a wheelchair for ADA compliance is 36 inches with at least 60 inches to make turns (ADA, n.d.). Often with gas pumps that face each other, the spacing between them is inadequate for 2 cars and the excess space needed to comfortably maneuver a wheelchair. Other accessibility issues for gas pumps is the ability to reach the card reader and pin pad and being able to read the screen. All these features were created based upon the measurements of a standing person, so individuals in wheelchairs may have difficulty, especially if they need to lean over a curb to do so. Increasing the space between gas pumps, implementing curb cutouts, having adjustable screens, and lowering the standard height of card readers and pin pads are all simple features that could improve accessibility of the gas pump for users with wheelchairs.

Drive-thrus

With the COVID-19 pandemic, there has been an estimated 43% increase in use of drive-thru food services as many dining rooms were closed (Bluedot, 2020). However, these drive-thru food services discriminate against people with various forms of disabilities. Various lawsuits against fast food companies have come about due to the inaccessibility of drive-thrus. There are many lawsuits surrounding individuals who are deaf or hard of hearing, who claim that the drive-thrus discriminate against them because they cannot order from the traditional sound speaker that is at most drive-thrus (Simmons, 2019). According to a survey of individuals who are deaf or hard of hearing, 42% have left a drive-thru without making a successful purchase and 94% said they would visit a restaurant that implemented systems to improve access to them (Inclusion Solutions, n.d.). Implementing an ordering system with paper menus, installing video boards at drive-thrus, and educating staff how to handle such situations are simple ways to make ordering at drive-thrus more accessible to users with difficulties hearing.

Figure 5.2: Example of a video drive-thru board (Taylor, 2015).

Drive-thrus are also not conducive for individuals with visual impairment and even some motor disabilities. Most individuals who are visually impaired, and even some who have motor disabilities, have limited access to a car or even someone to drive them. Drive-thrus do not allow people to walk through them, however with the pandemic and so many restaurants closing their dining rooms, these individuals have no way of getting their food. Implementation of a walk-thru, or wheel-thru, could give better access to these individuals while still maintaining safety for them.

Figure 5.3: A walk-up window implemented in a McDonald's for when the inside dining room is closed (FastFoodSource, 2013).

ATMs, Credit Card Readers, and Ticketing Machines

As previously mentioned, the implementation of touchscreens into ATMs has given rise to a greater challenge that people with visual impairments face when approaching an ATM or a credit card reader. Most of these struggles revolve around ensuring that the card is inserted correctly and knowing when to type in the user's PIN number. A study by Pino et al. (2014) examined the impact that introducing a series of beeps at critical stages of a point of sale (POS) transaction would have on improving accessibility for people with visual impairments. They utilized beeps of different pitches, durations, and frequencies to let the user know whether the card had been inserted correctly, when to enter their PIN number, and whether or not the PIN number had been accepted. Although there were no quantitative results, the collective qualitative feedback that the research group received from people with visual disabilities indicated a dramatic increase in comfort and confidence when using a point of sale transaction device (Pino et al., 2014).

There are several other emerging technologies for easing the process of keying in a PIN number into an ATM or a credit card reader. Another one of these proposed technological solutions is a system that accepts hand gestures as inputs from Das, et al. Their solution involves an enclosed box in which an ATM user can stick their hands into and perform numeric sign language gestures for selecting options that are audibly outputted to the user by the ATM. A

camera inside the box is able to capture the gesture, followed by a computer within the ATM translating the gesture into an input (Das, et al., 2015). Das, et al. expressed their belief that this technology could bolster autonomy for people with visual impairments, but it could be disadvantageous for users who do not know the sign language that the camera is programmed to read.

People with visual disabilities are not the only ones affected by the shortcomings of accessible features on POS devices; rather, there are different aspects of design that are needed to promote usability regardless of disability. In the case of people with cognitive disabilities, this can come in the form of retaining short-term memory while purchasing a ticket, a process that can often become lengthy. In order to aid individuals in navigating the transaction process, progress bars have recently been added to the visual display on the kiosk that highlight which steps have been completed, which ones are currently being processed, and which ones are left to complete (Veijalainen, 2017). Furthermore, there is a need for consistency in the steps necessary to purchase a ticket from a ticketing terminal (Pino et al., 2014). A standardized procedure for purchasing a ticket or using an ATM will significantly aid people with cognitive disabilities, for it allows them to commit the process to long-term memory through easily repeatable actions (Veijalainen, 2017).

Greater Universal Access

The accessibility features of SSTs ought to ease the transaction process for everyone, not just those who have a disability. This can come in the form of allotting ample space for wheelchair users to use a self-checkout machine at a grocery store (Bajaj et al., 2010), implementing audio prompts in a secure manner to maintain privacy for people with visual impairments (Pino et al., 2014), or organizing the transaction process into a standardized manner to allow for repeatability and consistency (Veijalainen, 2017). These accessibility features should not detract from ease of use for people who do not have a disability; they ought to streamline the process for all users regardless of ability.

Several interviews were conducted to investigate the impact that the presence, or the lack thereof, of intuitive accessibility features have on the lives of people with disabilities. One commonality between numerous people with various disabilities was the desire to live an independent life without having to rely on the assistance of other people to use SSTs. An interviewee who uses a wheelchair recommended simple changes for ATMs, such as elongating the funnel that credit and debit cards are inserted into to minimize the range of motion that users have to undergo while using the machine or ensuring that there are no curbs or other impedances surrounding the ATM to allow for a clear, spacious approach. Therefore, there is ample opportunity for changes in SST design that promote universal access for all users, not just those who have a disability.

Limitations with Advancements in SSTs for PWD

Current SST technology exhibits many limitations when it comes to specific disabilities. There is a need for SST technologies to be able to accommodate more disabilities instead of satisfying one accommodation and ignoring the rest. This section will review current SST features that limit accessibility for specific users.

Smooth touch screens are becoming more popular in SSTs because of the sleek high-tech look that they provide. Smooth touch screens limit those who are blind and rely on tactile assistance to get information. When a SST only offers a smooth touch screen, people who rely on tactile assistance have to ask for help defeating the purpose of SSTs.

SSTs have advanced to create a touchless experience for users over the years. Unfortunately, these touchless advancements are not helpful for everyone and for some, these advancements are harmful. These deceitfully harmful advancements in SSTs include voice command, QR codes, proximity sensors, foot pedals, and facial recognition.

Advancements in voice command technology have led to its implementation in SSTs. The use of voice command is well received as it allows users to avoid touching common surfaces when they use SSTs. Voice command presents limitations for people who are non-speaking or cannot speak clearly. The use of voice command is helpful for people who are blind or have limited mobility. Voice command is not a perfect solution for them though, because it cannot be used when they are dealing with sensitive information. For example, it would not be safe for someone to read off their bank information in a public space.

Quick response codes, better known as QR codes, are commonly used for contactless engagements in SSTs. QR codes are limiting for people who are blind or have limited motor control. People who are blind may have difficulties locating a QR code. The biggest difficulty with QR codes for people with low vision and blindness is that many QR codes are flush with their surface and have no tactile indicators. When QR codes are on a loose piece of paper, it presents additional limitations for people with low vision, as there is no way to know which side of the paper the QR code is face up. QR code menus have become common during the COVID-19 pandemic, but restaurants do not always clearly indicate which way the QR code is facing. QR codes are difficult to use for some people with limited mobility since QR codes require a steady hand to be read.

Proximity sensors are used frequently in touchless SSTs. Proximity sensors are not accessible to people who cannot move in a specific controlled manner like these sensors require. If the SST does not offer a way to use it without the sensor, then some people with disabilities are not able to use it. For example, many paper towel dispensers use proximity sensors as an indicator of when to dispense the paper towels. These sensors are frequently finicky and difficult for people without disabilities to use. In those cases, the SST can be nearly, if not, impossible to use for people with mobility disabilities. If the proximity sensor is small, flush with its surface, or lacks contrast; it can also limit users with poor visibility due to inability to know where to trigger the sensor.

Foot pedals are not touchless, but it offers a hands-free advancement in SSTs. Foot pedals provide a hands-free option for people who have visual or upper limb mobility impairments as well as limits the transmission of germs through hand touching.

Facial recognition is another touchless advancement for SSTs. However, SSTs that make use of facial recognition pose challenges for the visually impaired. Facial recognition requires the user to put their face in a specific location which can be impossible when the only feedback they receive is through a screen. Facial recognition also has issues regarding violations of privacy.

Future Game-Changing Advances for SSTs

What may be future game-changing advances in SST? Included in the section will be a specific look into self-service stations including drive throughs, gas stations, ATM machines, kiosks, and artificial intelligence assisted stations. This section will only be looking into future advances that are speculative or currently being researched.

Drive Thrus

A 2004 survey that collected information on individuals that are deaf or hard of hearing reported 78.4% of participants having difficulty placing food orders (Inclusion Solutions, 2004). This difficulty is caused by either the restaurant's inability to assist the individual or the individual not being able to communicate with the restaurant. The participants of the survey were then asked further how they felt about specific solutions to the problem. The participants were asked about two different solutions. The first solution was a call button being installed allowing the employees to be notified of their status of being hard of hearing or deaf. This solution had 82.7% of respondents indicate that they were in favor or neutral (Inclusion Solutions, 2004). The other solution that was asked about was to install electronic ordering systems at the drive through. This solution received a feedback of 96.2% either being positive or neutral (Inclusion Solutions, 2004).

With such a high percentage of participants indicating a positive response to electronic ordering systems, drive-throughs in the grocery and restaurant industry have installed some interactive electronic ordering systems such as touch screen kiosks (Figure 5.4) in conjunction with the previous method of the employee talking to the customer over an intercom system. This will allow for people that are hard of hearing or deaf to be able to place their own order in the drive through line instead of having to rely on the employee to help them order. In addition, this option would also allow people that do not wish to speak to order without having to interact with the employee over the intercom system.

Figure 5.4: A drive up touchscreen kiosk located in a drive through of a Which Wich (Keefner 2016).

When the ordering cannot be completed with an interactive electronic ordering system the drive through facility should equip a button allowing the customer to notify the employees working that they need assistance. This would be more appropriate for facilities where electronic ordering is infeasible such as medical and banking drive through stations.

The main concern for someone with a mobility impairment with drive-thrus is being able to reach and move around their car when either ordering, paying, or receiving their goods. Some problems that people with mobility impairment might face as the driver occurs when trying to reach or receive goods. When ordering if a button or kiosk has to be used the individual might

not be able to reach. This can be fixed by making sure not only is there an interactive electronic ordering system, but also an employee over the intercom to take the order. The next issue occurs when the customer has to either hand over payment or receive the goods. The customer might not be able to extend their arms and might not be able to handle the weight of the goods. A proposed solution for this was to develop a pop out window that could extend a tray out to the customer (Sharma alt al, 2020). This would allow the customer to pick the goods at a rate they can handle. This would also allow the customer to not have to reach as far as the goods could be extended to their window or even inside their window. Future technological advances can make this extending into a robotic arm that would help the customer with placing goods from a tray into their vehicle.

Artificial Intelligence Systems

Future artificial intelligence (AI) technology may allow users to interact with SSTs more fluently by anticipating their needs. One way that AI may grant better access for people is the ability for it to recognize individuals or their transaction preferences (Holmes, 2019). The ability to recognize individuals can be based on personally identifiable information, which stores user-SST interaction preferences or derived from how the user interacts with the SST. From either source of information, the AI system can tailor the user interface of the self-service station to that individual to provide a more accessible user experience. If the individual identifies as hard of hearing, the AI system can anticipate that this individual needs to either use a touchscreen kiosk or American Sign Language gesture recognition using computer vision based on the user's responses. If the AI system recognizes the individual as blind, it would assume the best way to communicate will be through verbal prompts. Likewise, the AI system would attempt to facilitate better service by recognizing that individuals with mobility impairments might need assistance physically reaching the SST or retrieving money or products from kiosks.

Hand Gesture for ATMs

Other methods that have been proposed that does not possibly infringe one's privacy have been proposed for the around 285 million people in the world who are visually impaired (Shruthi, 2015). This aforementioned advancement would redesign current ATMs to include a webcam with a resolution high enough to allow for it to understand and receive hand gestures which would be situated within a box so that their hand gestures are kept private (Shruthi, 2015). This box would be covered on all sides and have a hole underneath to allow for the hand to be inserted. On top of being able to read hand gestures the camera within the box would also be used for the person using it to show their card to the camera allowing it to read all the information instead of having to insert the card into the ATM like shown in Figure 5.5 below. They would use the hand gesture within the box to enter information such as pin or password, keeping their information private. Throughout this whole process the user would be wearing a headset connected to the ATM which would be notifying them if the system is translating their hand gestures or card reading correctly. This advancement to ATMs would in turn allow for the input of numbers through simple hand gestures (Shruthi, 2015).

Figure 5.5: Architecture of Proposed System (Shruthi, 2015).

Robotic Arms at Gas Stations

The fourth topic to be discussed is the research and development of a full service gas station by robotic arm at the pump. Gas stations normally are not suited to allow people with wheelchairs or physical impairments easy accessibility when having to pump gas. There are multiple companies who are working towards implementing robotic arms in gas stations which would make them much more accessible to people with disabilities.

The way in which this robotic fueling system would work is made up of a few key components that are around today. The first step in this process would be to use an RFID sticker that would be placed on the inside of the person's car which would contain the following information: car make and model, payment method usually tied to a card, and preferred gas type (Hall-Geisler, 2014). The gas pump would scan and read this information after pulling up to the pump and if their information is confirmed the fueling would begin. The robotic arm would then open the fuel cap, and if the car does not have a cap less fuel tank it would require a second arm with smaller hands to spin off the gas cap. Some companies would include a cap less solution that would allow people to replace their current cap with. There would be cameras located on the gas pump which would locate the fueling zone and would then begin inserting the gas spout to begin filling. Once the filling is completed the spout would be removed and the robotic pumping service would be completed allowing for a very simple accessibility for people with disabilities (Hall-Geisler, 2014).

Figure 5.7: Robotic arm opens gas cap and begins fueling (Hilkevitch 2014).

Currently there are a few issues to why there are not robotic pumping capabilities today. The first being the huge installation costs with today's technology. Hopefully, in a few years these costs will have decreased allowing for this to become a possibility but currently many of these could cost more than $100,000. The second would be that in the U.S. there are two states Oregon and New Jersey label it as illegal for people to pump their own gas so these states would not benefit from this solution currently (Marci, 2019).

Appendix A: Recommendations

1. Include closed captioning and pictures of menu items for drive-thrus or places where communication is completely verbal.
2. Allow PWDs to input interface preferences based on their disability when operating SSTs, thus merging customization with universal design.
3. More research is needed on how PWDs can better locate SSTs, and there is a need to implement more braille signs or input accessible locations into already available websites and applications.
4. It is important that those with disabilities are not forgotten as SST technology increases and evolves because new technology may help some but can also present new challenges for others.
5. There needs to be more consideration for a greater range of disabilities when making SSTs accessible as there is an extreme lack of consideration for those with cognitive impairments.
6. As adaptations have occurred in customer experiences, such as drive-thrus, due to the COVID-19 pandemic, PWDs may have been positively impacted by these changes in services, and it is imperative that these changes persist for PWDs as the pandemic evolves.
7. Additional standardization and universalization of accessibility laws and enforcement is needed between states and localities due to varying geographical interpretations and enforcement.
8. There should be increased precision of current disability laws that include more concrete definitions of the terms “disability” and “reasonable accommodations” to mitigate a lack of enforcement due to varying definitions of such terms.
9. There is a need to create a secure, accessible SST interaction for smartphones that involves a single app or a webpage and a near-field communication reader or Bluetooth.
10. More accessibility guidelines that are directly for app development used with SSTs are needed.
11. Security of kiosks needs to be increased and maintained to prevent malware from hacking both kiosks and phones of users, thus potentially accessing sensitive information.
12. All smartphones should be compatible with SSTs to reduce barriers to entry and access.
13. Ensure accessible SST options are clearly described on websites so that PWDs know what to expect before arriving.
14. There is a need to develop a method to receive consistent, unbiased feedback on SST accessibility from PWDs.
15. Strategies to financially incentivize business owners to increase accessibility would promote rapid, widespread progress and increase the customer base of the business.
16. The US Access Board should continue to utilize feedback from PWDs to improve SST accessibility standards.
17. Future advancements and integration of robotic technology should allow for easier delivery of goods and services such as robotic fueling at gas stations.
18. Improvements to Artificial Intelligence are needed to allow for verbal and signed language interactions as well as alternative forms of communication.
19. Artificial Intelligence should improve customizations of consumer preferences and remember consumer needs allowing for better information flow.

20. Future SSTs need to be designed with greater universal access in mind from the onset by creating features that are easy and comfortable to use.
21. PWDs should be consulted when designing SSTs to obtain their first-hand experience with how beneficial the new accessible design would be for them.

Appendix B: Methodology

The topic of self-service technologies had many aspects that needed to be considered when being researched. This included how current accommodations and solutions were performing, how smart phones are being used with SSTs, how access and success for SSTs can be measured, and foreseeable solutions that could change the game for SSTs. These topics cover the topic of SSTs well by providing information about how SSTs are in their current state as well as how they need to be improved and changed. The research and information for these topics was collected in three different ways which were literature reviews, interviews, and a survey. The target population for the interviews and surveys were people who use SSTs due to a disability as well as other shareholders in the SST industry such as fast-food restaurant and bank owners that were 18 years or older. All responses were kept anonymous in order to avoid bias and receive honest responses. The methodology used when conducting each of these three methods is detailed below:

Survey:

The survey was conducted using the web-based survey creator Qualtrics which is through Purdue University's Information Technology Department. The survey consisted of 25 questions that collected information from the target population about their background, how commonly and which SSTs they used, current frustrations with SSTs, and how SSTs should be changed to be more accessible. The data collected from this survey was analyzed by the team to show common responses and statistical significance of the responses. This survey was distributed in many different ways, but the primary method was having members of the team reach out to personal contacts that would fit under the target population. The survey was also distributed through Facebook groups, different organizations at Purdue that worked with disabled members, and centers for disabled people such as the Indiana School of Blind and the AWS foundation. The survey questions can be seen below.

Literature Review:

A comprehensive review was done using peer reviewed journals and articles discussing relevant topics related to SSTs. The list of peer reviewed journals and articles can be seen in the bibliography section of this paper.

Interviews:

The interviews were conducted in a variety of ways such as telephone, email, video calls using platforms such as Zoom or WebEx, and in person. These interviews included the discussed target population as interviewees which included people such as fast-food restaurant owners, people with disabilities who use SSTs, and clubs that work with disabled people. The list of interview questions can be seen in the appendix of this paper. The team would like to say thank you to those who took the time to be interviewed. Responses were extremely helpful in gaining an authentic perspective into the professional view alongside those with disabilities.

Survey Questions:

1. Please specify your gender (checklist):
2. Please specify you age range (checklist):
    a. 18-25

b. 26-35
c. 36-45
d. 46-55
e. 56-65
f. 66-75
g. 76+

3. Please provide a brief description of your disability. *(check all that apply)*
    a. Mobility
    b. Visual
    c. Hearing
    d. Intellectual
    e. Language/Reading
    f. Other (if this is chosen then text to explain)
4. Indicate which of the following Self-Service Technologies (SSTs) you commonly use? *(Check all that apply)*
    a. Kiosk
    b. ATM
    c. Payment (Credit Card) Terminal
    d. Voting Booths
    e. Gas Stations
    f. Drive Through
    g. Information Booths
    h. Vending Machines
    i. Other (please specify)
5. In your opinion, how useful were the selected SSTs in allowing you to complete a certain action? *(rating scale or text box to explain answer (or both))*
6. What is an SST that you commonly have difficulty with, and which of its features are hardest to use? *(short answer)*
7. What kinds of improvements would you suggest to make SSTs more functional and accessible? (touch screens, location, mobility around the kiosk, text reading capability, privacy, etc.) *(short answer)*
8. Which SST(s) do you think could benefit the most from technology advancements allowing for easier use, better accessibility, or greater universal access? (Check all that apply)
    a. Gas Stations
    b. Drive Through
    c. ATM
    d. Train Stations
    e. Information Stations
    f. Other
9. How often would you prefer using a SST or having a human assist you? (1- 10 scale making 1 only SST and 10 being only human assistance)
10. Do you regularly use any Assisted Technology (AT) to assist you with any of the previously mentioned SSTs? If yes, please explain.
11. How do you feel about the advancements in technology used in self-service kiosks? (Slider scale)

    a. It is not enough
    b. It is okay
    c. It is good
    d. It is excellent
12. Have you observed a change in a certain SST that you did or did not like? Please explain how the change impacted you. *(short answer)*
13. Are there certain companies that stick out to you as either good or bad examples of having good accessibility in their locations or products? These could include restaurants, technology companies, etc. *(short answer)*
14. Rank the following factors regarding SSTs from the most to least important: ease of use, self-sufficiency, time of use, privacy, and availability.
15. How easy to use are most SSTs on a scale of 1-5, 1 being the worst and 5 being the best?
16. How self-sufficient are most SSTs on a scale of 1-5, 1 being the worst and 5 being the best?
17. How timely to use are most SSTs on a scale of 1-5, 1 being the worst and 5 being the best?
18. How is the privacy of most SSTs on a scale of 1-5, 1 being the worst and 5 being the best?
19. How available are most SSTs on a scale of 1-5, 1 being the worst and 5 being the best?
20. How often do you use a smartphone? *(multiple choice)*
    a. Everyday for many hours (5+)
    b. Everyday for a few hours (2-4)
    c. Everyday for a limited amount of time (<1 hour)
    d. A couple times a week
    e. Almost never or never
21. How comfortable are you with using a smartphone on a scale of 1 to 5 (5 being the most comfortable)? *(multiple choice/sliding scale)*
22. What struggles do you have while using a smartphone? *(short answer)*
23. Would you consider using your smartphone to assist with any of the following self-service technologies? *(select all that apply)*
    a. Kiosks
    b. ATMs
    c. Payment at storefronts
    d. Voting booths
    e. Gas stations
    f. Drive thrus
    g. Other
    h. None of the above
24. What concerns, if any, do you have about using a smartphone with self-service technologies? *(select all that apply)*
    a. Privacy/security
    b. Ease of use
    c. App will not be accessible
    d. Other
    e. No concerns
25. Which changes to a gas pump would you like to see?

a. Extra space surrounding the pump and a longer hose to allow for easier movement around the pump
b. A retractable arm that is able to pump the gas for you without having to get out of the arm
c. An attendant that pumps gas for you
d. More than one of the above
e. Other

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