Overcoming Obstacles: Redefining Disability on Public Transportation

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Abstract

This thesis focuses on how technology can help improve accessibility on public transit. Through examining existing legislation surrounding disability rights in public places, it has become clear that accessibility issues are prevalent in public transit systems. Legislation has made much headway in removing physical barriers, but social issues that impede on people with disabilities' independence and decision-making when using public transit have yet to be rectified. Successful solutions to these less-physical obstacles must use technology creatively and explore how to equip passengers with the right tools to feel confident when using public transit, which ensures access to necessary resources and services.

Table of Contents

I. Introduction

Life presents us with many challenges, some minor, but others much more difficult. While most have experienced the truth of that sentiment firsthand, few communities understand its effects more than people living with disabilities. Everyday tasks that cause few dilemmas or moments of hesitation in many people's lives require special assistance for differently-abled individuals. Whether grocery shopping, boarding a bus, or even simply navigating the sidewalks, most of the world is not designed with those with disabilities in mind. Recently, attempts have been made to provide fair access to those with disabilities through social movements and the passage of legislation. While originally developed to inspire future growth in accessibility standards, these codes and laws have grown stagnant in their approach to remove barriers for those with disabilities. Now, they do little to combat some of the social challenges differently-abled individuals face when accessing and using public transit. However, prolific technological innovations and a human-centered design philosophy bring the promise of an improved and less obstructed future where products, services, and experiences can also satisfy the needs of the people with disabilities. Through examining standard accessibility guidelines, current disability rights and regulations, and focusing on the frequently-encountered barriers to public transit, potential solutions and design opportunities emerge and emphasize the positive impact of easy access to transportation in enabling those with disabilities to become confident and productive members of society.

a. What is a Disability?

Many people have different interpretations of what the word "disability" means. For this research, disability refers to a misalignment between a person's level of ability and their environment, and focus is mainly on accessibility barriers and technological solutions for people

living with permanent or irreversible disabilities. Specifically, mobility, cognitive, and visual impairments form the main communities under examination. However, acknowledging that personal perceptions of disabilities are unique, the research offers a rather objective perspective on the subject and aspects of the findings may be applicable to other types of disabilities. The research addresses general issues and creative solutions meant to enhance the quality of interaction with public transit by supporting people with mobility, cognitive and visual impairments through improved control over individual experience. Greater control over an individual experience with public transit is something from which many people of varying ability levels may benefit. Additionally, the information provides a basis for understanding the major barriers in using public transit for those with disabilities. While the research centers on those with permanent disabilities, the solutions are applicable to those with situational and temporary disabilities as well. Rather than developing accessibility solutions only for certain people, "accessibility encompasses many solutions and is best looked at as an on-going process of working towards including more people in meaningful ways" (Scherffius, 2018). In order to ensure that the solutions presented act according to these definitions of disability and accessibility requires some understanding of general accessible design principles.

b. What is Accessible Design?

When designing for disability, accessible design "refers to how something is designed to be used, reviewed, read, or otherwise accessed by someone who is living with a disability or impairment of some kind" (Scherffius, 2018). This is not to say that accessible design is only good for those with disabilities; in fact, the reality is quite the opposite. Accessibility indicates "intentionally designing the world to include everyone, regardless of disability" (Scherffius, 2018). Solving the accessibility issues for those with permanent disabilities—one end of the

disability spectrum—means that all types of transit riders may benefit, as designing for access often helps more than only those targeted. By adhering to accessibility standards in design or development, one cultivates a non-exclusionary atmosphere where everyone is afforded similar opportunities to live a well-fulfilled life. In short, the world becomes more inclusive and easier for everyone to navigate.

Certain design principles are imperative to creating accessible products, interfaces, and experiences, but, while they may seem like common sense, they are rarely fully implemented. These principles are applicable to different types of products and act as general guidelines to ensure effective communication between product and user. According to the Web Accessibility Initiative, such principles include refraining from cluttering content, presenting information through both visual and auditory means, and making content available through different routes of interaction (Zahra, 2017). By using simple terminology, short sentence structure, and white space to help delineate sentence breaks or the start of new information, designers ensure that those who interact with their products or interfaces can easily digest the general contents and calls-to-action. Designers should also provide access to information in a multitude of ways, such as through different entry points that lead to the same information, and by presenting content in different formats, depending on the needs of the person interacting with it. Although the Web Accessibility Initiative specifically targets "web accessibility requirements for websites, web applications, browsers," and other digital interfaces, designers of all fields can rely on these principles to guide their processes to achieve an accessible outcome (Zahra, 2017). For example, on a public train platform, these principles in action take the form of large-print signs that are also translated into braille, or screens that display the arrival time of one train at a time accompanied by a verbal announcement.

Though the digital interface design has revolutionized accessibility standards, other disciplines need to follow suit. People require accessibility in both digital and physical experiences. Following accessibility standards when developing either type of experience ensures that more people can use and interact with the result. Public transit is one such service in which people of all ability levels require ease of access to navigate from place to place. Incorporation of accessibility guidelines in all aspects of public transit design plays a crucial role in ensuring that transit riders know how to get to where they need to go.

c. Why Consider Public Transportation?

Areas like public transit system design and urban development have yet to catch up with digital interface design in terms of providing adequate accommodation for people with disabilities. This lack of accommodation negatively affects the lives of people living with disabilities by impeding on their right to access the same resources, services, and experiences as everyone else. For anyone who uses it, access to public transit means transportation to important places like grocery stores and doctors' offices, and it also means increased opportunity to find and maintain a job, especially for those who cannot drive on their own and usually rely on others for rides. For the over 40 million Americans living with both physical and cognitive disabilities, many times "these [transit] systems represent the only viable option to live independently, socialize, or hold a steady job" (Carmien et al., 2005, p. 234).

While some may recommend owning a personal accessible vehicle, the price is often too high for those with disabilities to manage, which emphasizes the necessity of access to public transit. When considering those using wheelchairs: "accessible consumer van upgrades—adapting for lifts, ramps, safety tie-downs, and automated systems that allow for transfer from a wheelchair to the driver's seat—can cost upward of $75,000, and thousands more per year to

fuel, maintain, insure, and park" (Wright & Johnson-Wright, 2018). People living with disabilities are often forced either to rely heavily on others for travel, resources, and money, or to go without, due to the inability to easily utilize public transit, as well as the great expense of personal vehicles that many are unable to afford.

Improving accessibility to public transit allows differently-abled individuals, who normally require assistance when travelling, to benefit from an increased sense of independence. Confidence in one's abilities to do things independently yields a more engaged, well-functioning member of society; however, because of the current state of public transit, "in order to have the freedom to live independently, socialize, or hold a job, one must be able to understand and navigate cognitively complex systems," a feat that is challenging enough for those without any sort of impairment (Carmien et al., 2005, p. 234). The complexity and level of understanding that public transit systems require to plan and travel through set routes severely limit the number and type of people who can successfully utilize it as their main method of transportation. For those with disabilities who do rely on it, this complexity "directly and adversely affects autonomy, community participation, and socioeconomic position. (Bezyak, Sabella, & Gattis, 2017, p. 56). Not only does inaccessible public transit mean that some people must live without everyday necessities that many take for granted, but it also means that differently-abled individuals often miss out on meaningful interactions with other people and the chance to build confidence as an independent community participant.

Public transit has the capacity to alter society by providing people with a safe, reliable method to acquire important resources, experience social interaction and acceptance, and increase autonomy and personal confidence. For many people and communities, public transit is

not simply a few bus or train stations, but a pathway to freedom and the bridge to a fuller human experience.

II. Existing Regulations

Legislators have enacted years' worth of standards for disability access to public transit systems through laws and mandates. The focus of such laws has recently shifted from providing for the rehabilitation facilities and caretakers of those with disabilities to securing and empowering the social participation of the differently-abled individual. Before the Americans with Disabilities Act (ADA) in 1990, if a business or venue failed to provide access to those with disabilities they faced few, if any consequences: "there were no inspections, nor were there any fines" (Guffey, 2018, p. 142). This lack of enforcement against discrimination and exclusion still affects areas of accessibility today. Even with laws in place and the awareness of accessible public transit, the lack of will to see those with disabilities as equal members of society still inhibits the success of many acts, rules, or regulations recently enacted.

a. The Architectural Barriers Act (ABA)

The effort to promote the rights of those with disabilities came alongside other civil rights movements in the U.S. from the 1960's and on. In 1968, the U.S. government passed the Architectural Barriers Act (ABA), which was "one of the first pieces of federal disability rights legislation to protect all people with disabilities" (Petrick, 2015, p. 13). The ABA required accessible design and construction of certain Federally-funded buildings, but it offered little guidance into what constituted as an acceptable level of accessibility or how to enforce any regulations it set out. For example, while an amendment to the ABA in 1970 included the Washington, D.C. Metro, then under construction, as needing to be accessible, it took a lawsuit

against the Washington Metropolitan Area Transit Authority in 1972 to begin enforcing the ABA (Petrick, 2015, p. 13). While its intent was meaningful for the community of those with disabilities, the reality of the ABA left much undone in way of progress towards inclusion of disability rights.

b. Section 504 of the Rehabilitation Act

Section 504 of the Rehabilitation Act of 1973 is another piece of groundbreaking legislation passed to support the inclusion of people with disabilities, following the passage of the ABA by a few years. The Section reads:

> "No otherwise handicapped individual in the United States, as defined in section 7(6), shall, solely by reason of his handicap, be excluded from participation in, be denied the benefits of, or be subjected to discrimination under any program or activity receiving Federal financial assistance." (as quoted in Petrick, 2015, p. 15)

Ideally this addendum to the Rehabilitation Act would have worked in conjunction with the other laws in place to eliminate exclusion of those with disabilities from activities that received funding from the Federal government, including usage of some public transit systems. In reality, both Section 504 and the ABA merely prohibited discrimination without providing active guidance on how to eliminate that discrimination, leaving many obstacles still in place. If any real change were to take place in creating accessible experiences, "buildings, workplaces, and educational institutions would have to be physically altered and specialized tools provided in order for people with disabilities to fully participate in society" (Petrick, 2015, p. 17). Public transit remained a point of contention for this reason, as the entire operation of transit systems needed massive adjustments to accommodate those with disabilities.

c. Movements toward Accessible Transportation

Even when the right tools were available, though, accessibility needs were still not met. In 1981, a group of people with mobility impairments who used wheelchairs wished to board a Los Angeles bus; however, they soon discovered that the newly-added lifts on the bus were completely unusable, their deployment took too much time, and their use threw off the entire bus schedule. The group also found that the annoyed bus driver, unwilling to do much to reconcile the issue and get the passengers on board, offered little help (Guffey, 2018, p. 141). The following year, another issue arose centering around the lack of enforcement of accessibility standards on public transit when a group of people with mobility impairments brought a lawsuit against Chicago-area public transit services in the case, *Lloyd v. Illinois Regional Transportation Authority*. The courts ruled in favor of the Illinois Regional Transportation Authority, expressing that the existing regulations set out by the ABA and Section 504 were permittable but not mandatory to enforce. The results of this case solidified the perceptions that the courts viewed the prohibition of discrimination of people with disabilities as an "unenforceable issue," and did not consider the rights of those with disabilities as a priority to uphold (Petrick, 2015, p. 18). Although this attitude continued, and some may argue it continues today, the protests and persistence of differently-abled individuals to keep their needs visible to the government forced change on accessibility rights in years to come.

d. The Americans with Disabilities Act (ADA)

Soon after these conflicts in the 1980's, then-U.S. President George H. W. Bush signed the Americans with Disabilities Act in 1990 with the hopes to resolve the problems that the lack of enforcement of previous legislature had caused. Many praised the ADA after its passage, some going so far as to compare its impact to the Civil Rights Act and movement of the 1960's

(Guffey, 2018, p.155). The ADA, still in place today, expands upon previous legislation by prohibiting discrimination of those with disabilities in public places like jobs, schools, transportation, and privately-owned places that are open to the general public. The ADA also "guarantees equal opportunity for individuals with disabilities in public accommodations" by setting a minimum standard for accessibility in the new construction of public facilities ("What is the Americans", 2018). Specifically, Titles II and III of the ADA outline accessibility accommodations pertaining to public places and public transit, whether or not these locations receive federal funds. Title II describes the "administrative processes to be followed, including requirements for self-evaluation and planning; requirements for making reasonable modifications to policies, practices, and procedures where necessary to avoid discrimination; architectural barriers to be identified; and the need for effective communication with people with hearing, vision and speech disabilities" ("What is the Americans", 2018). The ADA completely changed how the public view people with disabilities, and it supports equal access for everyone regardless of ability. Whether in acquiring a job or travelling to-and-from that job, the ADA allows differently-abled individuals to feel a sense of equality with the rest of society by eliminating physical obstacles in public and privately-owned businesses as well as the decreasing the social barrier of discrimination by enabling people of all ability levels to access the same services and experiences.

e. The Gray Area

Nevertheless, the ADA left some things open to interpretation, making its universal enforcement all the more challenging. Specifically, regarding exactly what barriers existing buildings and facilities should remove, the ADA specified that business owners should make "reasonable modifications" as they saw fit "without much difficulty or expense" to accommodate

those with disabilities ("What is the Americans", 2018). Because of this, many found it easy to ignore the ADA at its inception, especially smaller businesses who could not absorb the costs of modifying their spaces to accommodate differently-abled individuals like some larger businesses. While few businesses tried to openly defy the ADA, few also spoke out about their compliance with it. Designers, builders, and architects— "even those who supported disabled people's rights to access"—greeted the ADA with hostility or hesitation, uncertain in the depth of research behind the premise of the Act and the bureaucracy of the regulations it set out (Guffey, 2018, p.158). Yet, the ADA remains the primary legislation determining accessibility and disability accommodation in the United States.

f. The Impact of Disability Rights Regulations

The level of accessibility to public transit systems greatly improved with the passage of the ADA. The removal of physical barriers "clearly changed the landscape of public transit," and brought upon improvements to overall accessibility for those with disabilities (Bezyak, Sabella, & Gattis, 2017, p. 52-53). In fact, the recent implementation of the Americans with Disabilities Act Amendments Act in 2009, which endorsed a broader definition of "disability," requires that public facilities, including public transit systems, must consider people of a greater range of abilities when designing for those with disabilities.

These improvements to public transit do not diminish the effect of the poor enforcement issues of the ADA, but instead illustrate that legislation is only one of the first steps in working towards accessibility for all. Gabe Klein, author and co-founder of CityFi, a management firm for urban change that collaborates on a variety of urban-planning and mobility projects across the globe, agrees: "I think when agencies focus only on the Americans with Disabilities Act, they can get too focused on just meeting minimum ADA requirements. That's when we lose track of

truly making a place accessible for people with disabilities" (as quoted in Wright & Johnson-Wright, 2018). Accessibility to public transit systems, while improved with the help of the ADA and previous legislation, still does not meet the needs of all those living with disabilities; the rules and regulations, while passed many years ago, lay a firm foundation for advancing upon with the use of modern technology and design. Using the ADA as a framework when thinking and designing creatively may provide a way to diminish the discrimination that still exists by making access easier for everyone, as well as enabling those with disabilities to feel less reliant on others and more confident in their own capabilities.

The passage of some of the most monumental legislation to expand the rights of those with disabilities happened over thirty years ago, but modern society and disability accommodation still require change. While society has come a long way, to fully achieve what the ABA, Section 504 of the Rehabilitation Act, and the ADA set out to do, it must continue to push forward in the direction of increased access in public and private venues for people of all levels of ability. Meant to be a starting point in granting differently-abled people the same rights and protections as anyone else, these laws have now grown stagnant in their approach for providing an equal quality of life for those with disabilities because of their lack of enforcement, clarity in guidelines, and capacity to cover all types of accessibility issues. Building upon existing laws and regulations as is necessary to begin moving towards a more accessible future once again.

III. THE ISSUES THAT REMAIN

Although the ADA instigated many improvements to physical obstacles in public and private facilities, "individuals with disabilities still experience barriers to public transportation,

and improvement efforts have plateaued in the last 10 years" (Bezyak, Sabella, & Gattis, 2017, p. 59). Again, established legislation, while important, cannot be expected to greatly impact accessibility on its own. This lack of impact has been exhibited in previous difficulties with enforcement and guideline specificity. "Communities that want to make a real commitment to providing effective, inclusive mobility, must take compliance with the ADA seriously," but they must also do more (Wright & Johnson-Wright, 2018). Existing laws and regulations provide the foundation that modern advancements and perspectives must build upon to truly see an increase in accessibility efforts in public spaces, like public transit stations.

Even though accessibility should promote access for everyone, despite type or level of disability, the 2017 research from Bezyak, Sabella, and Gattis supports the idea that "people who are blind/have low vision and people with mobility impairments/used wheelchairs experience a higher number of barriers to public transportation than other disability categories, suggesting greater need for interventions related to these populations" (2017, p. 57). For that reason, the main problem points outlined in the remainder of this paper will focus on the needs of these two communities, as well as those with cognitive impairments. Additionally, some support will be offered as to how other populations could benefit from similar solutions. In fact, the problem areas of dealing with social stigma, interacting with information, and wayfinding are common areas with which many people take issue, including those with visual, mobility and cognitive disabilities.

a. Social Stigma

The stigma that living with a permanent disability makes someone "less than" exists still today, even though legislative action has tried to prohibit disability discrimination. Unfortunately, this stigma is highlighted by both those who ride and those who operate public

transit. Some of those without disabilities lack consideration for differently-abled individuals who may require special accommodations and more time to board or de-board transportation vehicles. One of the most shocking conclusions from the 2017 research of Bezyak, Sabella, and Gattis is that "three out of the top six barriers to public transportation experienced by people with disabilities were related to characteristics of the driver, including drivers not calling out stops, inappropriate driver attitude, and driver's lack of knowledge" of disability etiquette (p. 56). Much like the bus driver at the 1981 conflict in Los Angeles, present-day public transit operators get away with discriminatory behavior that inhibits the use of public transit for those with disabilities, especially in situations with individuals whose disabilities are more visible, like the mobility and visually impaired (Bezyak, Sabella, & Gattis, 2017, p. 57). When those with disabilities require assistance that those operating public transit vehicles do not know how or want to provide, the result is uncomfortable and stressful for both, which increases the solidification of any pre-existing stigmas that may inform future behavior or encounters between the two parties.

However, as noted earlier, the attitudes toward stigmas surrounding disabilities are held by people living without permanent disabilities who use public transit, in addition to the drivers and operators. In fact, the behavioral and emotional responses of other transit patrons may influence how the drivers react to situations with people with disabilities. The main tension point between those with and those without disabilities on public transit is the inconvenience it causes to accommodate a person with a disability. For example, when a bus driver stops and must deploy the wheelchair ramp for a patron with a mobility impairment, he or she must park close to the curb and deploy the ramp, which takes three minutes more on average for the bus to depart from the stop than when the ramp is not needed. "Thus for a bus line having 30 bus stops, 90

more min are needed if the bus driver has to park carefully and deploy" the ramp (Zhou, Hou, Zou, 2012, p. 10680). For those without disabilities relying on public transit, this accommodation throws off their personal schedules, in addition to altering the bus's schedule for those waiting at upcoming stops. To avoid angry or irritable passengers, or even just to avoid the inconvenience of deploying the ramp, some drivers may not stop at all when they see a passenger with a mobility impairment or falsely claim that their vehicle's lifts or ramps are inoperable. If they do stop, they may not take the necessary precautions to ensure that the ramp is deployed correctly to safely board the passenger who requires it (Bezyak, Sabella, & Gattis, 2017, p. 53). To avoid situations like these from continuing to occur, more than legislation is needed; at the very least, those who work for public transit companies should know and understand the significance of how to handle disability accommodations properly, but a more successful route may be to explore how to equip those with disabilities with a way to manage their personal travel experience without much assistance from other people.

b. Route Planning & Symbol Comprehension

Another one of the main impediments to accessibility in public transit systems that reduces the amount of confidence with which differently-abled individuals act is the level of comprehension and dependency on visual ability required to understand routes of travel. As these issues present a large cognitive barrier, those with cognitive impairments will be addressed more in this section than in the previous. For people with disabilities, cognitive and physical, knowing the route of travel before navigating it is an important step in their interaction with public transit. Unfortunately, the current state of public transit requires the ability "to comprehend, manipulate, and process essential navigation artifacts (i.e., maps, schedules, landmarks, labels and signs, and clocks) encoded often in compact and efficient representations" (Carmien et al., 2005, p. 237).

Because these navigation artifacts are "compact and efficient" the high level of deduction required to fully understand what is illustrated creates cognitive burdens on those with disabilities, and visual or cognitive impairments may contribute to the struggle of interpreting station maps, schedules, and signage into an accurate understanding of the station layout.

For this reason, many spend vast amounts of time extracting their personal trip information from transit websites and digital mapping applications before departing on their routes, as well as memorizing specific routes that they are likely to frequently repeat (Carmien et al., 2005, p. 242). When such routes of planned or repeated travel are interrupted, due to vehicular delays or venturing out at a new time of day, differently-abled individuals, specifically those with cognitive impairments, can experience high-levels of stress which "may cause them to panic or abort previously mastered routes" (Carmien et al., 2005, p. 243). Additionally, attempting to use public transit for the first time or from a new stop has the potential to cause emotional or mental strain due to the unexpected variables that may interfere with the steps to get from one place to another: upon arrival, travelers must "identify that they are at the correct place; they must locate a fare machine and pay; [and] they need to find the correct location for boarding the vehicle in a station" (Lewis et al., 2011, p. 5). At every step of the way, from entering the station to boarding the vehicle, potential barriers and stressors exist. Those with disabilities need a way to feel confident in their capacity to encounter new routes, unexpected delays, or unfamiliar transit stops by adapting to such situations without requiring much, if any, outside assistance.

c. Wayfinding & Stop Declaration

A report by the Transportation Research Board (TRB), a division of the National Research Council of the United States that provides research-based solutions to transit issues,

concludes that other common issues for those with disabilities who use public transit include knowing when to exit at the right stop and understanding operators' announcements of stops (Carmien et al., 2005, p. 238). This result from the TRB's research indicates that knowing when and where to disembark from a public transit vehicle is just as important as understanding the stations and routes themselves, but that the lack of alerting of upcoming stops is a frequent and substantial barrier to those with disabilities. Public transit stop declarations usually rely on audio cues, like operator announcements or recordings played when approaching a stop. For those with hearing difficulties, these types of declaration already present a problem, but the inaccessibility only increases when considering that sometimes stop announcements are not made at all, and other times, the condition of announcement system prevents clear audio communication between passengers and the operator, forcing those with disabilities to rely on, if they are able, visual indicators, intuition, or the assistance of another passenger to know when they have reached their desired stop (Bezyak, Sabella, & Gattis, 2017, p. 53). In order to best equip those with disabilities with the resources and information they need to successfully navigate public transit, designers must the address complexity of signage, schedules and general station information available, as well as ensure that personal route details are easily available to reduce the need for outside assistance.

IV. Potential Technological Solutions

a. Addressing the Obstacles

Combatting social stigmas presents its own world of challenges, so the approach to reduce the inconvenience those without disabilities feel when using public transit alongside someone with a disability requires creativity; a solution must empower differently-abled

individuals rather than expect a change in the attitude of society. Jana Lynott, manager of the American Association of Retired Persons'(AARP) transportation and research agenda, confirmed the need for new design implementations to improve public transit when she said, "we need to design transit systems that everyone in a community—regardless of money, or physical or cognitive ability—can use," (as quoted in Wright & Johnson-Wright, 2018). Overcoming the issues encountered by those with disabilities is a step in the right direction, though this is no easy feat. The theme of enabling those with disabilities to handle and overcome their personal obstacles when interacting with public transit systems also carries over to the potential for solutions to inaccessible wayfinding and information presentation. Because of the limitation to address the needs of different disabilities, route information, station signage, and stop declarations frequently hinder how comfortable and confident those with disabilities feel while using public transit. If those who design public transit systems can develop a way to ensure that differently-abled individuals understand how to interact with public transit and feel comfortable while doing so, then the level of accessibility will increase, and those with disabilities can confidently overcome the obstacles that may have once seemed irresolvable.

b. Human-Centered & Universal Design

Certainly, some alterations to increase public transit accessibility require an increased awareness of space and physicality that allows those with disability to feel and sense their way safely throughout transit stations and vehicles, including "smooth, obstacle-free sidewalks; and ample space to wait and board safely at transit stops" (Wright & Johnson-Wright, 2018). For the other accessibility issues previously discussed, however, technology offers potential solutions because the field has recently experienced tremendous growth in terms of human-centered design principles that can apply to numerous areas of public transit systems. Human-centered design

focuses the development of new and the implementation of current technology on what people need and want out of an experience rather than on solely what will profit or satisfy business needs the most. In adhering to these principles and ideas, public transit presents numerous opportunities for technology to redefine the way those with disabilities interact and maneuver from one place to another.

Additionally, those working with technology have welcomed the idea of "universal design," where one design accounts for and accommodates people of all levels of capability and understanding, which is applicable to improving accessibility through designing for different types of people. To illustrate how transportation may embrace the ideas of universal design, consider the Complete Streets movement, which started in Oregon around 1971 and has now expanded across the United States. The movement, alongside the help of the National Complete Streets Coalition, makes use of the universal design principles by advocating for "wider, well-maintained sidewalks; safe, well-marked crosswalks; more accessible bus stops; and better elevator access to underground or elevated commuter rail" (Wright & Johnson-Wright, 2018). Complete Streets ensures that people of all different levels of abilities have better access to "housing, jobs, civic opportunities, medical care, recreation, and more" by taking into account not only the level of ease for people travelling to transportation stations, but also the level of safety within those stations for people with varying abilities (Wright & Johnson-Wright, 2018). To consider issues of transportation accessibility both broadly and in depth, the Complete Streets movement and Coalition prioritize supporting designing for disability, knowing that by doing so, everyone benefits. With much the same goal in mind, using the principles of universal design to integrate technology and transportation can have profound impact on the way every individual uses public transit.

c. Reducing "Inconvenience"

One of the main barriers to public transit use that those with disabilities encounter is the attitude of fellow passengers and vehicle operators. Because of this prominent barrier, it is important to examine the potential of technology to make the use of transit more efficient for differently-abled individuals, which would reduce the level at which those without disabilities feel inconvenienced. Through aiming to help multiple groups of people, who have very different perspectives on the same problems, each may receive a solution that is satisfactory and improves their use of public transit (Lewis et al., 2011, p. 18). Those with disabilities become more self-confident by supporting less reliance on the assistance of others and general independence by providing technological solutions to issues with route planning, wayfinding, and stop declarations. Technological solutions that better equip those with disabilities to use public transit, also mean less work for transit operators to accommodate them and, as a result, less schedule hindrances for other passengers. By utilizing assistive technology for route planning, implementing accessible wayfinding, and allowing passengers personalized access to transit information, public transit can become a well-integrated, synergistic system. Ideally, this type of system would run efficiently enough to where each passenger is confident to ride independently, without having to worry about whether they will be adequately accommodated. A synergistic transit system has many parts that must work well together, most of which are outlined in the following sections before section iv illustrates this type of system in action.

i. Assistive planning & web-based tools.

Highly complex technological options complicate the route to solve complex problems, so instead simple solutions usually suffice. Because those with disabilities often find planning personal transit routes important before venturing out, public transit system websites should

observe web accessibility principles to ensure that, regardless of ability, people can understand and interact with the information they need. Websites can provide interactive maps, scalable to different levels of visibility, and present clear, concise route or stop information in multiple ways, like through text and audio. Additionally, the implementation of planning tools on public transit websites could prove effective by reducing the number of steps someone must go through to find, organize, and access their trip details. These small changes to digital interfaces could greatly impact not only the efficiency with which those with disabilities plan their transit use, but also the confidence with which they carry out their ready-made plans by knowing where to board, how long trips may take, and where to find help if they need it.

ii. Accessible wayfinding & navigation.

Straightforward technological solutions also offer much promise in improving the public transit experience through clarifying station navigation and wayfinding. For anyone, "the preference is always to do these things independently and not rely on fellow travelers or station staff for information" (Lewis et al., 2011, p. 16). Much like digital content, public transit stations should ensure that signage and directional information is accessible by providing a few different options on how to receive it. For those with cognitive impairments, the size of and spacing between words on signs with safety or directional information is very important, and, if vehicle arrival times are displayed on a digital display board, people should have plenty of time to read and comprehend the information before the screen changes. "For the visually-impaired person, from first arrival at a train station, there is no way to read the train time display board—in this situation a button on a kiosk could easily tell a traveler everything they need to know" by providing clear audio updates at a volume discernable above traffic or patron noise (Lewis et al., 2011, p. 16). Additionally, those with visual impairments should have access to any safety

materials or guidelines posted in the station or vehicle through a similar procedure. For those with mobility impairments, the aforementioned technological solutions would work as well with some additional consideration to their placement, i.e. so that people can reach buttons with little effort or arm extension necessary, and people can see screens from an upward angle with little interference as necessary when in a wheelchair. Through these methods, public transit becomes more accessible to those who struggle with the current wayfinding systems by reducing stress about how to use transportation, and disabilities do not prevent the capacity to navigate a transit station independently by eliminating certain barriers that prevent proper information gathering on one's own. Still, exploring a slightly more sophisticated technological solution may further assist in addressing issues with accessibility in public transit.

iii. Personal & integrated technology.

Most people go everywhere with a personal mobile device nowadays, which can be used advantageously to support the independent needs of those with disabilities while using public transit. In fact, if public transit utilized this widespread dependency on smart phones and portable devices, many accessibility issues may become obsolete. Specifically, these devices could present personalized information based on an individual's route or location on an accessible digital interface that each person could customize and manipulate to suit their needs. For example, a mobile application could provide a route planning tool, an up-to-date arrival time board, and personal route duration or delay information. To alert an individual when his or her stop is approaching, the device could offer some type of notification or feedback in a format that is accessible to the individual, helping to distinguish when the vehicle is at another stop versus when it is time for him or her to disembark (Bezyak et al., 2017, p. 58). Pure reliance on a personal device to provide information is not enough to truly ensure accessibility, but in

conjunction with station and signage modifications, using a mobile application or something of the sort ensures that no matter what, each passenger can access the same information as everyone else.

For this type of system to work, the platform with which differently-abled individuals interact - or any other passenger for that matter - needs to account for varying levels of ability and comprehension from its users. One solution may be to utilize voice-recognition technology that can "vastly simplify user interfaces with handheld devices, like cell phones, allowing users to access many functions and make complicated requests without wading through layers of menus" (Burt et al., 2008, p. 65). Voice recognition may simplify understanding of the digital platform and allow users to find the information they need more efficiently: someone could tell his or her phone "to retrieve route and schedule information from a transit website, and the phone would automatically coordinate the information transfer" (Burt et al., 2008, p. 65). Perhaps voice recognition technology would also be valuable if it was reciprocal, meaning the device could also speak back to the user, able to interact with different languages or types of speech, as well as used throughout transit stations and vehicles in addition to on personal devices.

Nevertheless, public transit systems still operate without effectively using technology to reach passengers, meaning the technology that is used is often not well-integrated throughout the transit system. "Rather, most [technology] systems are implemented and operated separately, in a stand-alone fashion, and, consequently, synergistic benefits are not realized" (Burt et al., 2008, p. 2). Currently, the need to learn multiple separate technologies acts as a large barrier to use in public transit systems, as different, but perhaps equally important, information is in different areas of the station and on different digital platforms, resulting in more processes to learn and

rely on. For those with disabilities, this extensive learning process is neither easy nor enjoyable, and it adds to the confusion and obstacles to overcome when attempting to use public transit. There is a need to "fully integrate real-time information and communication systems to make them accessible in a simple format to all, across multiple languages, media, and platforms" (Lewis et al., 2011, p. 12). If stations connected payment, boarding, directional, and customer service information into one dynamic and completely integrated system, overall accessibility would likely increase due to the narrowing of information outlets that individuals would have to learn or interact with to successfully use public transit (Burt et al., 2008, p. 61). Cooperating systems can lessen the cognitive barriers some face in understanding transit systems while increasing their accessibility by allowing individuals to interact with and manipulate information to suit their personal needs.

iv. Synergistic public transit in action.

Utilizing assistive tools and providing accessible information on personal platforms ensures that the important parts of the transit system cooperate with one another and provide a seamless experience to the passenger who can understand what is pertinent to them and act accordingly. To take the idea of a sense of synergy a step further, consider what building accessibility into the stations and vehicles themselves may look like, in addition to employing the previously mentioned solutions. Using technology to ensure that the stations and vehicles communicate with one another and with the passengers may just be the missing link to create a better functioning public transit system.

Employing this increased synergistic approach, the Mobi+ system, originated and deployed in buses and stations of line 2 in the city of Clermont-Ferrand, France, aims to integrate passenger and transportation information communication. Mobi+ developers chose to focus their

preliminary efforts on developing this system for buses because they tend to be the preferred transportation method due to their frequency and high number of stops; however, once fully established, the system could be used similarly for other forms of public transit (Zhou, Hou, Zuo, Li, 2012, p. 10679). The Mobi+ system consists of three subsystems that work together to form an assimilation of human-computer interaction specifically for those with disabilities, referred to as disabled, wheelchair, and blind passengers (DWB) by the researchers:

> "a wireless communication subsystem, which provides the data exchange and network connection services between buses and stations in the complex urban environments; the bus subsystem, which provides the DWB class detection & bus arrival notification services; and the station subsystem, which implements the urban environmental surveillance & bus auxiliary access services." (Zhou, Hou, Zuo, Li, 2012, p. 10678)

In other words, a technological network exists to facilitate communication between the different pieces of the Mobi+ system – detection of type of disability and bus arrival times, as well as station displays and surveillance. Within this system, a differently-abled individual would receive an identification card, called an "RFID" tag, at a transit station that would specify their type of impairment. This card, when inserted into the RFID reader at a station or stop, would then communicate with the station and bus to alert all the intertwined systems of someone with a disability. When a transit vehicle approaches a stop, a low-frequency buzz begins and a light flashes intermittently at the station because of the communication between the bus and the station set in motion by the RFID card reader. Not only do these signals notify people with disabilities that a vehicle is approaching, but they also help to inform the driver or operator of the transit vehicle that someone with a disability is at the next stop, allowing them to anticipate the situation and execute proper maneuvering and accommodation in as short of time as possible

with reduced potential of driving or ramp deployment errors (Zhou, Hou, Zuo, Li, 2012, p. 10688). The Mobi+ system illustrates the advantages to a cohesive relationship between public transit and technology to increase accessibility for those with disabilities, and, while the system is currently only in use on bus routes, all types of public transit vehicles and stations could use the basic design of the system to aid in accessibility efforts.

Implementing something along the same lines as the Mobi+ system means better communication between public transit passengers, stations, vehicles and operators. With better communication comes an increased sense of preparedness to handle upcoming situations, like accommodating a disability, where the people involved can act more efficiently and confidently. A synergistic system reduces the level of inconvenience of those with and without disabilities in public transit situations by promoting more passenger reliance on the system itself rather than on other people.

d. Arguments against the Cost of Accessibility Initiatives

Some people will find fault in the ideas of implementing any sort of technology or system into public transit systems and stand firmly against them. Because not everyone using public transit has a disability, one could argue, it may not make sense to complicate the learning curve for those who do not have disabilities to accommodate the few that do. Mainly, many would argue against the cost of developing and building these accommodating features—it is costly enough just to bring the existing stations and vehicles up to current codes, so the cost for anything new would surely be exorbitant. Those who do not see a need to increase public transit accessibility and even those who do not use public transit would also likely have to help fund such projects through taxes, which, to them, may seem unfair. Additionally, once accessibility projects are funded, people may also find inconvenience in the construction process which often

interferes with traffic and travel time. Some may even question if the positive outcomes of an accessible transit system outweigh the troubles it would cause to create such a system, especially since those who experience the challenges would not all necessarily identify with living with disabilities.

e. Responding to Arguments against Accessibility

Those with disabilities experience an extremely important sense of liberation from dependency on others to provide for or take care of them when public transit is accessible. By feeling as though they are capable of confidently using public transit on their own, their self-confidence increases alongside the number of resources and services to which they have safe access. As noted previously, building confidence in those with disabilities is vital to their human experience and creates invested members of society who have a fair chance at living happy, fulfilling lives.

However, accessible public transit can positively impact everyone who relies on it as a means of transportation, not just a choice few. Proven in the past, assistive technologies and products designed to accommodate those with disabilities usually turn into something beneficial to everyone (Lewis et al., 2011, p. 12). Consider that the garage door opener, used by many to easily secure and offer access to one's personal car garage, "was originally designed for a quadriplegic," or that curb-cut outs, that act as a safer way to cross the street from sidewalk to sidewalk, "were originally incorporated for wheelchairs" (Lewis et al., 2011, p. 12). In fact, one could argue that no one goes about their daily life without experiencing the hindrances of disability, whether they are permanent conditions or temporary or situational. Some may have mobility impairments and permanently use a wheelchair, while others may experience mobility impairments temporarily from a broken leg, or situationally from holding a child, but each

condition represents a very real, very common impediment on the way each person goes about navigating a public transit station. By designing for permanent disabilities, those experiencing temporary or situational disabilities also reap the rewards of improved access. While it is hard to deny the financial costs of creating accessible public transit, the process and results are an investment in a safer, smarter tomorrow where the benefits for everyone greatly outweigh any hesitations or opposition.

V. For the Future of Accessibility

a. Disability Awareness & Empathy

Public space and service accessibility has come a long way in the last fifty years, but it must go further; the future of accessibility lies in the minds of designers, developers, architects, engineers, and so many others who have the metaphorical blueprints to build upon. They must remember to create and construct for people of all abilities. Because the legislation is already in place and the technology exists, all that seems to be missing is the creativity in approaching potential accessibility solutions. Parties involved in planning, funding and designing public transit systems need to consider new ways to include accessibility and to consider those with varying levels of ability.

i. Including disability in the discussion.

The chances of success at which new accessibility solutions may operate greatly improve by encouraging those with disabilities to play a part in determining issues and conceptualizing possible routes for design opportunities. The empathy of designers and developers can only grow from frequent interaction with others who are not like them, and it can significantly improve the outcomes of their design processes by addressing audiences of all types of experiences,

backgrounds, and ability levels. Promoting an awareness of disability is important so that the crafters of tomorrow understand the widespread potential impact of their work on all types of people. The way in which this promotion and increased interaction between designers and those with disabilities is done may require additional research and evidential support.

ii. Disability education.

Another important factor that has the potential to strongly influence the future of accessibility is education about disabilities and disability etiquette. As societal changes are not expected immediately, advocating for attitudinal changes and stigma avoidance must start at a more centralized point with the hopes that demonstrative behaviors will encourage others to feel or act similarly. For example, employers might require programs teaching how to accommodate and interact with different types of disabilities for their employees; a better understanding of different types of impairments may yield greater empathy from those who interact with differently-abled individuals, including public transit employees. Such programs and their success rates would provide an interesting path for further research to determine how to best implement disability awareness at different places of employment.

b. Accessible Ride-Share

Another interesting area of research relating to transportation for those with disabilities is ride-sharing, such as Lyft and Uber (Streeter, personal communication, October 24, 2018). Ride-share options offer many of the same solutions as access to public transit, yet ride-share drivers are not often equipped to transport passengers with disabilities. As this becomes a more prominent system to travel around, ride-sharing will need to start offering viable options for differently-abled passengers, especially those who do not live in areas with existing public transit systems nearby.

c. Concluding Remarks about Future Research

The research presented here offers only the beginnings of insight into making public transit more accessible. While many have tackled the topic before, there are still many areas to explore and examine to truly ensure that those with disabilities are not excluded for transportation innovations of all types. Building compassion and expanding knowledge of disabilities offer the most challenges in dealing directly with people's attitudes, but with more research into how to properly execute educational programs, they increase hope for a more empathetic interaction between transit employees and passengers with disabilities. Also, because technology is ever-evolving, the promise it holds to better accessibility becomes stronger with every iteration; new technologies, like ride-sharing, could be the solutions to problems not currently addressed regarding accessible transportation for those with physical and cognitive disabilities alike. As with most anything, further exploration and research may provide insights currently lacking and impact the way those with disabilities travel.

VI. Conclusion

Life presents each of us with numerous challenges, some more demanding than others. However, it is possible to improve the quality of life we all live through things that already exist. Technology can play a role in creating an accessible society. With increasing knowledge and empathy for people of varying ability levels, technology has the potential to initiate change and positively affect how people interact with the world. Technological implementations, in conjunction with enacting and enforcing current legislation to designate the rights of those with disabilities, as well as advocating for empathy and awareness of disabilities and impairments,

make the future seem more accessible for everyone. While some may choose to focus on the inconveniences of implementing methods of accessibility into public transit systems, the costs are well worth the result, especially when viewed as an investment for benefit of the whole rather than an expense to accommodate the few. By developing public transit systems with disabilities in mind and using principles of universal and human-centered design, differently-abled individuals benefit by increased access to necessary resources and job opportunities, and they grow more confident in themselves and their ability to make positive contributions to society. Those without disabilities benefit as well, as temporary and situational disabilities are accounted for and accessibility transform public transit into an easier-to-use system and less stressful or inconvenient experience. While there is still much to be done in terms of crafting an accessible world, technology, when used creatively, offers a step in the right direction to accommodate those with and without disabilities on public transit.

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