Autonomous Vehicles and Accessibility: A case study of the benefits and challenges posed by autonomous vehicles to people with disabilities

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The integration of autonomous vehicles into society once seemed like science fiction or a far-off dream, but it is now very close to becoming reality. Autonomous vehicles are already on the roads of several countries, and their popularity is constantly growing. With their rise in popularity, autonomous vehicles could bring many benefits to the transportation industry such as increased accessibility, improved safety, lower greenhouse gas emissions, and more (Cohen et al., 2020). These potential benefits, however, may not be seen by many groups hoping to take advantage of this new technology. Furthermore, security risks, financial accessibility, safety concerns, and other challenges may cause groups currently disadvantaged by the transportation industry to be further marginalized (Bennett et al., 2019). This paper looks to explore the benefits and challenges posed by the rise of autonomous vehicles to marginalized groups through a case study of one of these groups: people with disabilities. The research will also analyze different autonomous vehicle designs and regulations, and ways in which different autonomous vehicle trajectories can best serve the disabled community.

Current Transportation Industry

Before exploring how people with disabilities could be impacted by autonomous vehicles, it is important to understand their relationship with the current transportation industry. People with disabilities often have decreased access to privately owned vehicles, as several types of disabilities such as visual impairments, cognitive disabilities, and ambulatory difficulties restrict one's ability to operate a vehicle (Claypool et al., 2017). Therefore, people with disabilities are often reliant on rides from friends and family or public transportation to go places that are not walkable. The efficacy of public transportation or paratransit is significantly

dependent on the user's location – big city buses and subways are often the best way to quickly move around urban spaces, but in rural and suburban locations, public transportation options are extremely limited and sometimes nonexistent (Bennet et al., 2019). Even in urban areas, however, people with disabilities still face challenges with public transportation. In 2017, Bezyak et al. conducted a study of people with disabilities which found that almost half of the participants reported that an inadequate transit system was a substantial barrier to using public transportation. Furthermore, inaccessible routes or stations, inappropriate driver attitudes, and drivers not calling out stops were other barriers reported by over 25% of respondents (Bezyak et al., 2017). Thus, people with disabilities not only have physical restrictions that limit their access to transportation, but also face inadequate resources and support to take advantage of existing public transportation. These accessibility issues persist despite Title II and III of the Americans with Disabilities Act, which require that public and private transportation services provide the same transportation services to people with and without disabilities (U.S. Department of Justice, 2020).

People with disabilities who have access to transit services have been found to have increased social interaction, which influences overall well-being (Blais & El-Geneidy, 2014). On the other hand, a lack of reliable transportation options adversely impacts independence and involvement with one's community, as transportation is often needed to access employment, medical services, and more (Hwang et al., 2020). Therefore, access to transportation should be not be seen as a luxury, but a right. The presence of transportation options, however, does not necessarily imply access to these options, and this disparity is especially seen by members of the disabled community who are unable to drive and face obstacles using public transportation. Autonomous vehicles have the ability to significantly increase transportation accessibility for

people with disabilities, leading to higher employment rates, better community living, improved access to and lower cost of healthcare, and more (Clayton et al., 2017).

Autonomous Vehicle Futures

While many researchers agree that autonomous vehicles will overtake human-operated vehicles in popularity, there is debate concerning how autonomous vehicles will be integrated into society. Cohen et al. (2020) describes two possible autonomous vehicle futures that will frame the study of how people with disabilities are impacted by autonomous vehicles in this research. The first is privately-owned autonomous vehicles, where people own autonomous vehicles and use them similarly to how human-operated vehicles are currently used, except that a driver is not required to operate the vehicle. The second autonomous vehicle future is one where the transportation evolves into mobility-as-a-service systems, where vehicles are not individually owned but instead owned by companies. In this scenario, customers would pay to use the vehicles in a per-ride method, similar to how companies like Lyft and Uber operate today (Cohen et al., 2020). Although there are many other possible autonomous vehicle futures, this research will examine the unique benefits and challenges posed to people with disabilities by these two futures.

Privately-Owned Autonomous Vehicle Future

The most obvious benefit of the rise of autonomous vehicles for people with disabilities is that people who were unable to operate a human-operated vehicle now have the ability to do so. Privately-owned autonomous vehicles would help improve geographical access to transportation, as people in rural areas often have less public transportation options than those in urban areas. Furthermore, privately-owned vehicles have the ability to be customized, which is

beneficial for people who use mobility equipment that cannot fit into certain vehicles. Some users may also feel more comfortable or safe in their own vehicle, since they are able to keep track of the vehicle's maintenance and upkeep. Privately-owned autonomous vehicles would be more convenient for many users because they are available to use anytime.

Despite these potential benefits, privately-owned autonomous vehicles could adversely impact transportation accessibility to people with disabilities. An issue already seen today with privatized autonomous vehicles is their high cost. Not only are autonomous vehicles expensive to purchase, but buyers are also responsible for maintenance costs, gas, and insurance payments (Claypool et al., 2017). The National Highway Traffic Safety Administration (2015) reports that people who modify human-operated vehicles for mobility equipment requirements pay anywhere between $20,000 and $80,000, and it is likely this range will become more expensive with autonomous vehicles. Although rebates averaging around $1,000 and government-backed loans are available for these modifications, the cost of mobility modifications to a vehicle are significant (National Highway Traffic Safety Administration, 2015), and would disproportionately impact lower class, middle class, and even upper-middle class people in the disabled community.

Mobility-as-a-Service Autonomous Vehicle Future

A mobility-as-a-service autonomous vehicle future would be very different than the transportation infrastructure present in the U.S. today, but it could potentially benefit several marginalized groups, such as people with disabilities. The main benefit of mobility-as-a-service systems would be a lower overall cost to users. Given that vehicles which accommodate mobility equipment are available, a user with this equipment could avoid paying to modify a privately-owned vehicle. This is already cost efficient, but would save users even more money if they do

not use a car frequently. Users would also not need car insurance to use a vehicle, nor would they pay directly for any vehicle maintenance. People with disabilities noted this financial advantage in a survey conducted that gathered their opinions and perceptions of autonomous vehicles (Hwang et al., 2020). The survey also found that people with disabilities were excited about the possibility of mobility-as-a-service systems so that they would not have to deal with public transit locations that are either inaccessible or public transit vehicles with inadequate space (Hwang et al., 2020).

A possible downside to a mobility-as-a-service system would be that people in different geographic regions would not get equal access to vehicles. Urban areas would likely have more vehicles available for service because more users are located in those areas. Furthermore, people with disabilities in rural and less populated areas would likely have to pay more and wait longer for services, as the cars would need to travel further to pick them up or drop them off (Cohen et al., 2020). Even if these mobility services became equally available in rural areas, it would likely cause significant infrastructure costs to the areas (Cohen et al., 2020). People with disabilities that use mobility equipment may also need to pay higher service charges for vehicles that are large enough to fit the equipment, as well as deal with longer wait times (Louise et al., 2018). In some cases, the mobility equipment may not fit in any available vehicle, worsening the already low access to transportation for people with disabilities.

Accessibility Challenges

While each of these futures presents their own benefits and challenges to people with disabilities, it would be remiss to not analyze how different autonomous vehicle trajectories impact different groups of people within the disabled community. The needs and preferences of people with disabilities are incredibly diverse, especially in the context of transportation

(Claypool et al., 2017). Different designs, futures, and regulations of autonomous vehicles will affect subsections of the disabled community differently, and it is particularly important that different stakeholders keep this in mind so that the rise of autonomous vehicles is able to bring as many benefits to as many people as possible.

Since autonomous vehicles do not require a human operator, some control system must be present so that users can direct the car where to go and customize other settings, like temperature regulation or music. The user interface for the control system will likely either be auditory or visual, or a combination of both. An auditory interface would be beneficial to people in the blind and visually impaired community, but would exclude those who are hearing impaired or deaf. Conversely, a visual interface would meet the needs of hearing impaired and deaf people, but would not accommodate people who are blind, visually impaired, or have a physical disability that prevents them from interacting with a screen or control devices (Claypool et al., 2017). A control interface using both visual and auditory components, however, would exclude all of the aforementioned groups, unless they are designed in a way where the vehicle could also be controlled exclusively through voice or through touch.

It is likely that autonomous vehicles will continue to be introduced as privately-owned vehicles until public skepticism has decreased and the majority of vehicles on the road are autonomous (Cohen et al., 2020). Furthermore, introducing widespread autonomous vehicles through mobility-as-a-service systems would cause significant disruption to current transportation infrastructure. Thus, we can assume that at least for a few years after autonomous vehicles become the dominant form of transportation, they will be privately owned. Therefore, people with disabilities who cannot afford to purchase autonomous vehicles- which will almost definitely be more expensive than human-operated vehicles- will be unable to reap their benefits.

The issue of financial accessibility could potentially be mitigated by government loans or other financial assistance, but even so, there would still be some people unable to use autonomous vehicles until they become much more affordable.

The mobility-as-a-service system of autonomous vehicles could also present disproportionate advantages to different groups of the disabled community if not regulated. Companies like Lyft and Uber, a rideshare service, currently have the ability to connect customers with drivers who have vehicles equipped with wheelchair lifts in some major U.S. cities (Drive A Wheelchair Accessible Vehicle, n.d.; Wheelchair Policy - Lyft Help, n.d.). While this technology is beneficial to people in those areas, other people with disabilities that require mobility equipment outside of these locations are unable to use these services. If autonomous vehicles eventually become mobility-as-a-service systems, this issue must be prevented so that those with mobility equipment can also take advantage of increased transportation access. While it seems sensible for ride service companies to employ accessible vehicles in large cities, it may not be as financially advantageous for companies to have accessible services in more rural areas, especially if there are very few people who need those accommodations. To mitigate this issue, the government could financially incentivize these companies to offer services accommodating mobility equipment nationwide.

Another challenge that threatens people with disabilities' ability to use autonomous vehicles is the level of autonomy the vehicles would operate at. It is widely agreed upon that autonomous vehicles will navigate themselves from one location to another, but in the event of an emergency, would the vehicle still be completely autonomous? Some studies have found that public opinion favors a design of autonomous vehicles in which a human driver has the ability to take control of the vehicle (Haboucha et al., 2017). If this idea is incorporated into a design, it is

unclear if the vehicle would be considered less safe if there is not an available driver to take over control. Further, some people with disabilities have expressed concerns that following an accident, they would be unable to call for help, exit the vehicle, or make it to their destination (Bennett et al., 2019). These concerns are elevated for people with severe physical disabilities, as well as people in the intellectual and developmental disability community (Claypool et al., 2017). Worries of safety risks make it even more important for autonomous vehicle manufacturers and designers to incorporate a universal and accommodating design in their vehicles.

Not only does the design of autonomous vehicles benefit and challenge the disabled community differently, but so does regulation. A regulation that could significantly hinder transportation accessibility for a subsection of the disabled community is the requirement of a licensed driver to be in an autonomous vehicle while it is in use (Claypool et al., 2017). Under this type of restriction, people with disabilities that prevent them from obtaining a driver's license would be unable to independently use autonomous vehicles. There are currently driving automation laws in six U.S. states which require a licensed operator to be in autonomous vehicles while in use (Autonomous Vehicle Laws, 2021). While it is unclear if the safety regulations will change as autonomous vehicles become more popular, it would be unfair to automatically restrict so many people in the disabled community from gaining the benefits of autonomous vehicles.

Stakeholders in the Design and Regulation of Autonomous Vehicles

Many autonomous vehicle manufacturers believe autonomous vehicle popularity is exponentially growing, and some are advocating for driverless roads before 2050 (Ross, 2014). With widespread autonomous vehicle use being so close to reality, autonomous vehicle

manufacturers are doing everything they can to increase public optimism about handing over the wheel. A study surveying drivers from the U.S. and Israel found that 44% of participants had a strong preference for human-operated vehicles, and 25% of participants refused to ride in an autonomous vehicle even if the ride was free (Haboucha et al., 2017). Given high levels of public hesitancy, autonomous vehicle manufacturers will likely design vehicles to satisfy the needs and concerns of the largest customer groups to yield the most profit. Thus, it is important that the needs of the disabled community are not overshadowed in the design process. In order to ensure the most universal designs are used, a diverse group of stakeholders need to be present in both the development of autonomous vehicles and the creation of autonomous driving legislation.

Due to the clear potential benefits to the disabled community, some autonomous vehicle manufacturers have already begun to incorporate accessible designs into their vehicles. In 2015, Google released an advertisement for their autonomous vehicle featuring a blind person travelling around Austin, Texas in one of their vehicles (Hwang et al., 2020). Shortly after, Tesla also stated their autonomous vehicles featured a fully autonomous driving mode (The Tesla Team, 2016). Autonomous vehicle manufacturers should be incentivized to use a universal design for their vehicles, not only because it benefits people with disabilities, but also because different users will have different preferences in terms of how they can control the vehicle. Incorporating a design accessible to multiple groups within the disabled community could also improve public opinion of autonomous vehicles, as people often prefer supporting companies that are known to promote social good (Spodarczyk, 2019).

While companies should be motivated to expand their potential customer group as much as possible, some accessibility accommodations might be costly. High costs may prevent companies from including them, which would exclude certain groups within the disabled

community from using autonomous vehicles. To mitigate this, the government could offer financial incentives, like tax cuts or funding, to these companies in return for utilizing a more universal design. The government could also offer subsidies directly to people with disabilities that face a higher cost of services than other users to accommodate their needs. To ensure government funding is put towards autonomous vehicles, however, the needs and requirements of the disabled community must be communicated clearly and loudly to both legislators and autonomous vehicle manufacturers.

There are many advocacy groups for people with disabilities that have a strong national presence and are qualified to communicate the needs of different groups within the disabled community. While many advocacy groups exist for specific disabilities, the American Association of People with Disabilities, the National Disability Rights Network, and the Arc are some of the groups that advocate for people with disabilities by doing advocacy work such as lobbying for legislation and promoting policies that support equity and rights (Disability Advocacy Groups, 2016). Not only can these groups amplify the voices of the disabled community, but research can also help discover the opinions and needs of different groups of people with disabilities. Little research has been conducted on the thoughts of the disabled community in regards to autonomous vehicles (Bennett et al., 2019). Conducting more studies and research on this topic would increase knowledge on the diverse needs of the disabled community, which could ultimately result in more accessible autonomous vehicle designs being implemented.

Conclusion

The top two challenges people with disabilities face regarding transportation are limited access to public transportation and no access to a private vehicle according to a survey conducted

by the U.S. Department of Transportation (Hwang et al., 2020). As such, people with disabilities are a group that potentially stands to gain the most from the rise of autonomous vehicles. Individually-owned autonomous vehicles and mobility-as-a-service systems both pose unique advantages and challenges to different groups within the disabled community, but both of these future trajectories would generally increase the number of accessible transportation options for people with disabilities. In order for the most benefits to be reaped, however, stakeholders in the autonomous vehicle industry need to understand the diverse needs of people in the disabled community and implement these requirements into the design and integration of autonomous vehicles. Regulations regarding autonomous vehicle accessibility and safety should also reflect this by gathering input from different members of the disabled community as well as different advocacy groups.

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