Preparing for a Driverless Future

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16. Abstract

Autonomous vehicles (AVs) are widely considered to be the future of surface transportation in the United States, but little is understood about how people will interact with these vehicles, what they will use them for, and how they will impact our roads. However, farmers have been interacting with some degree of AV technology, primarily auto-guidance, in Nebraska for at least the last 10 years. The research in Section 1 first utilizes in-depth qualitative interviews to understand farmers' experiences with using highly automated technology in order to inform adoption and diffusion patterns of AVs. The findings in Section 1 lead to a discussion of the implications for on-road AVs for technology adoption, infrastructure, AV users, and public policy which each hold relevance for engineers, planners and policy-makers seeking to be proactive in preparing for AVs. Section 2 applies concepts revealed through the interviews with farmers to inform a statewide survey of Nebraskans. Section 2 focuses on understanding what issues related to access and mobility currently exist in Nebraska and how AVs might address those needs. By examining areas of need as well as Nebraskans' perceptions of AVs, Section 2 explores both the challenges and opportunities AVs present for Nebraska. Together, the interviews and statewide survey of Nebraskans detailed in this report offer illustrative insights for the planning and preparation of AVs. While much of the existing research on AVs focuses on the benefits for tech-savvy urbanites, this research focuses on the needs of Nebraskans in urban and rural areas. The findings of this report reveal that driverless vehicles offer potential benefits, particularly for rural Nebraskans (most notably older individuals) who live far from vital services and resources. The implications from this research will help decision-makers in Nebraska be best prepared to proactively prepare for AVs and become a national leader in driverless vehicle technology and implementation.

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EXECUTIVE SUMMARY

Autonomous Vehicles (AVs) are widely considered to be the future of surface transportation in the United States, but little is understood about how people will interact with these vehicles, what they will use them for, and how they will impact our roads. However, farmers have been interacting with some degree of AV technology, primarily auto-guidance, in Nebraska for at least the last 10 years. The research in Section 1 first utilizes in-depth qualitative interviews to understand farmers' experiences with using highly automated technology in order to inform adoption and diffusion patterns of AVs. The findings in Section 1 lead to a discussion of the implications for on-road AVs for technology adoption, infrastructure, AV users, and public policy which each hold relevance for engineers, planners, and policy-makers seeking to be proactive in preparing for AVs.

Section 2 applies concepts revealed through the interviews with farmers to inform a statewide survey of Nebraskans. Section 2 focuses on understanding what issues related to access and mobility currently exist in Nebraska and how AVs might address those needs. By examining areas of need as well as Nebraskans' perceptions of AVs, Section 2 explores both the challenges and opportunities AVs present for Nebraska.

Together, the interviews and statewide survey of Nebraskans detailed in this report offer illustrative insights for the planning and preparation of AVs. While much of the existing research on AVs focuses on the benefits for tech-savvy urbanites, this research focuses on the needs of Nebraskans in urban and rural areas. The findings of this report reveal that driverless vehicles offer potential benefits, particularly for rural Nebraskans (most notably older individuals) who live far from vital services and resources. The implications from this research will help decision-makers in Nebraska be best prepared to proactively prepare for AVs and become a national leader in driverless vehicle technology and implementation.

SECTION 1

How Prior Experience With Automated Technology Impacts Perceptions of Autonomous Vehicles: A Case Study of Midwestern Farmers

Introduction

There is a great deal of speculation around the impacts and implications of autonomous vehicles on our roads. Proponents of the technology suggest that Autonomous Vehicles (AVs) will improve safety and efficiency on our roads, reduce transport-sector emissions, and improve delivery services. But any potential benefits of AVs depend on individual's willingness to use the new technology. Diffusion of innovations theory is often applied to explain how technological innovations will spread across time; however, much existing diffusion of innovations research in the literature on autonomous vehicles is limited to examining the perceptions of those with little to no direct experience with the technology. This research aims to shed new light on actual uptake of AV technology by learning from the experiences of those who have extensive experience with similar technology: farmers with years of experience using automated (rather than autonomous) technology.

Automated technologies have played an important part of American agriculture for the last 20 years by improving the precision and efficiency of farming equipment while also reducing operator strain and fatigue. This research aims to learn from the experiences of those in the agriculture industry with experience using automated and partially-autonomous farming equipment to better understand adoption decisions of autonomous vehicles. By focusing on a population with extensive knowledge and experience of automated and partially autonomous agriculture technology, this research offers new perspectives to better understanding potential AV adoption and diffusion.

This is a qualitative study, using thick descriptions, derived from a series of in-depth qualitative interviews with farmers and others in the Midwestern agriculture community to answer two guiding research questions: 1) *How have leaders in the Midwestern agriculture community experienced automated farm equipment?* and 2) *How does usage with automated farm equipment impact views of fully autonomous technologies?* The findings from this research span four themes: technology adoption, misaligned expectations, challenges with the technology, and perceptions of the technology. From these themes, we offer relevant implications for autonomous vehicle technology development, user experience, infrastructure requirements or expectations, and public policy considerations.

Literature Review

Significant advancements in autonomous transportation technology in recent years increase the prospect of a driverless future. Autonomous transportation technology has gained wide interest, for a host of reasons, including the potential to improve roadway safety and efficiency, mitigate roadway congestion, improve fuel economy, reduce long-term roadway infrastructure maintenance and management costs, and enhance service delivery [1, 2, 3]. In the United States, there are more than 35,000 fatalities and 2 million injuries as a result of traffic collisions annually [4]. Autonomous vehicles (AVs) are widely presented in the literature as a means to potentially address traffic collisions caused by human errors and improve traffic safety [5]. Additionally, AVs have been touted for their ability to expand transportation access and mobility for people with disabilities and those unable to drive, such as children and aging adults [6, 7, 8].

The potential benefits of AVs depend on the extent to which people are willing to adopt the new technology. To predict and explain AV adoption trends, much existing research utilizes diffusion of innovations theory. The theory is used to explain how a particular technological innovation might spread across a population over time [9]. Rogers (2003) categorizes the population into five adoption categories: a few very early adopters (innovators) followed by a gradual increase (early adopters, then early majority) [10]. According to the model, the rate of adoption will slow during the late majority phase and then finally plateau during the laggards stage. Collectively, when displayed graphically, diffusion of innovations theory forms an "s-curve" and is useful to predict adoption patterns. Rogers emphasizes the importance of reaching critical mass of an innovation adoption in order to ensure its success.

According to diffusion of innovations theory, each individual actor follows a sequential decision-making process consisting of five stages: knowledge, persuasion, decision, implementation, and confirmation. The process recognizes that as a person becomes more knowledgeable about the innovation being considered, they will make a decision whether to adopt based on a set of perceived advantages or disadvantages. If the innovation is adopted, then it goes through the implementation phase, and if determined useful, then the confirmation stage. A limitation of existing diffusion of innovations theory research is that many existing studies base their conclusions on scenarios with decision-makers in the early stages of the model.

Our research addresses this gap in diffusion theory by seeking to learn from a unique population that has direct experience with all stages of the decision-making process. In the literature on AVs, existing studies primarily focus on the earlier stages of the decision-making process by exploring user perceptions. These studies largely require study participants to speculate what actions they would take in hypothetical scenarios with technology they have no experience using [see, for example, 11, 12]. Studies focused on user perceptions of AVs that make inferences about early adopters further tend to be limited by their focus on urban populations, who tend to be less reliant on the automobile, and more familiar with related transportation innovations, such as bikesharing, carsharing, and e-scooters [for example, 13, 14, 15]. In contrast, our study seeks to learn from the experiences of a population living in auto-dependent areas, with extensive experience with automated and partially-autonomous farm equipment, offering new insights into planning for the future of AV adoption and diffusion.

While drivers are becoming increasingly accustomed to driver-assist technologies (e.g., lane-assistance, back-up cameras, and blind-spot detectors), their impacts have been modest. In contrast, over the last 20 years automated farm equipment has revolutionized the American agriculture industry. Early methods of automated agriculture, often called precision agriculture, use GPS based systems to distribute agriculture products in the field more efficiently than conventional methods. Precision agriculture has evolved to encompass a wide range of activities, including, variable rate applications, precision soil sampling, guidance based and auto-steer, and yield monitoring. Specifically, auto-steering technology enables farmers to travel in a pre-determined path, allowing the equipment operator to focus on functions other than driving. Because the auto-steering technology used in agriculture equipment is similar to the technology being developed for autonomous vehicles, farmers with extensive experience with the technology are an important yet often overlooked study population. By understanding of the experience of first-hand users of automated technology, this research can better understand the implications of AVs.

Methodology

This research uses a qualitative methodology designed to explore experiences with automated farm equipment in order to better understand autonomous transportation technology adoption. In so doing, this study offers a novel addition to the literature on AVs. Much of the existing literature on adoption of AVs is strictly quantitative in nature [see, for example, 16, 17]. Much of the existing AV literature relies on surveys or travel demand modeling to forecast adoption. A previous study examining farmer perceptions of automated agriculture technology is limited to quantitative methods (best-worst scaling choice experiment) [18]. Rich qualitative data is well-positioned to add new insight into understanding how experiences with automated equipment might inform perceptions of AVs and adoption patterns. Unlike quantitative research, qualitative research is descriptive; it seeks to explain social phenomena and the contexts in which they occur by using thick descriptions [19, 20, 21]. Since this study seeks to learn from the experiences of those who have used automated agriculture technology, such questions necessitate a systematic and analytic approach offered by qualitative inquiry. This research first answers the primary research question:

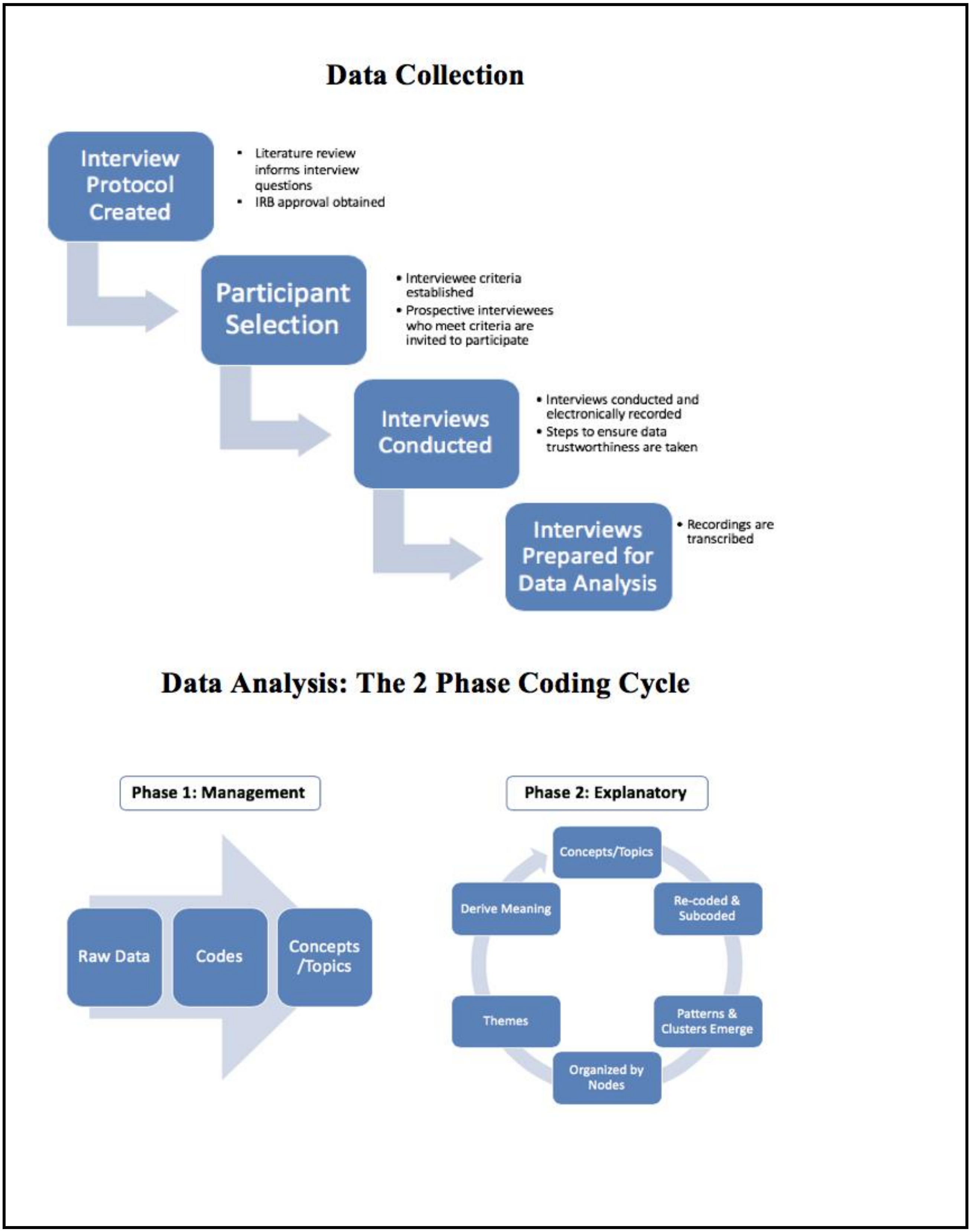
> *How have leaders in the Midwestern agriculture community experienced automated farm equipment?*

Additionally, this research answers the following secondary research question:

> *How does usage with automated farm equipment impact views of fully autonomous technologies?*

Since this research is designed to gain a thorough understanding of experience, perceptions, and views, we utilize a series of semi-structured, in-depth interviews with leaders in Midwest agricultural industry. The robust qualitative procedures for data collection and analysis used in this study are depicted in *Figure 1* and described in greater detail below.

Figure 1: The Qualitative Interview Research Process



Data Collection

The Midwest United States has long played an important part in American agriculture, growing crops such as corn, soybeans, wheat, hay, beans, and potatoes. Midwest farmers also have extensive experience with automated farm equipment, making them ideal population of study for this research. Semi-structured interviews or “conversations with a purpose” [22, 23] reveal new insight on a topic by forming a partnership between interviewee and interviewer [24].

This study utilized a purposeful sampling method for selecting participants [25]. Prospective interviewees were identified based on their prior experience using automated farm equipment and/or particular knowledge of automated agricultural technologies. Of the 11 interviewees, the primary job of 8 participants was grower/farmer. In selecting participants, an attempt was made to select growers working in a diversity of geographic areas; 2 of the growers operate fields within close proximity to urbanized areas and the remaining 6 operate in fields located in rural areas. The other 3 participants work for different companies in the Midwest developing and/or selling automated and autonomous farm equipment. These participants held the following titles: Systems Engineer; Technology Developer; and Product Training Specialist.

Prospective interviewees were initially contacted by email where they were introduced to the study, made aware of participant rights, and invited to participate in an interview at their convenience. Once interviewees agreed to participate in the study, a telephone interview was scheduled. All participating interviewees were guaranteed confidentiality.

To improve validity of the findings, the telephone interviews were recorded, transcribed, and hermeneutically analyzed [27, 28] using MAXQDA software. The interviews ranged in length from 17 to 45 minutes with an average of 29 minutes per interview. The interview questions were intentionally designed to be open-ended and gain a better understanding of experiences with automated agriculture equipment. The questions centered around adopting automated technologies, challenges in using automated equipment, perceptions of automated technology, attitudes toward fully autonomous technologies, using automated and autonomous equipment on public roads, and opportunities for autonomous vehicles impacting the agriculture industry.

Data Analysis

Interview transcripts were thoroughly analyzed using the qualitative coding software MAXQDA. The coding occurred in two stages. The first stage sought to organize the data around concepts pertaining to the research questions and the second stage sought to establish trends and themes across the data so that meaning could be understood [29]. The following primary codes were derived from the data: adoption, impact of automated farm equipment, impact of fully autonomous farm equipment, perceptions of automated equipment, perceptions of autonomous vehicles, experience informs autonomous vehicle perception, trust in autonomous vehicles, public roads, farm equipment-vehicle interaction on roads, user interface, and challenges with automated technology. Using a systematic cyclical coding process enables meaning of the data to be generated and understood [30]. Data triangulation was achieved by both researchers checking the data for consistency and drawing on multiple sources of data during the data analysis phase. The researchers used techniques described by Maxwell (2013) to check for "validity threats" during the data analysis process that could lead to alternate explanations of the findings [31].

In order to be transparent and promote authenticity, the presentation of the findings relies on thick descriptions and direct quotations from interviewees [32].

Findings

Participants in this study had a wide range of experience with automated agriculture technologies, but all were well versed in their capabilities. All interviewees have experience using precision agriculture technology, autosteering, and rate controllers. Several interviewees also have experience with more advanced camera-, sensor-, and radar-based technology on agriculture equipment. This section will first present the findings surrounding farmers' experience with using automated technology. Discussions of why farmers say they adopt new technology, how their perceptions of automated technology have evolved post-adoption, as well as farmers' challenges experienced in using automated agriculture technology will each be discussed in turn. The second part of this section will describe how farmers' experience with automated technologies shape their perceptions of fully autonomous technologies. The focus of this discussion reveals how prior experience with automated technology leads farmers to be concerned with the capabilities of AVs on public roads. *Table 1* presents an overview of the findings, each of which are elaborated upon below.

Table 1: Overview of the Findings

Theme	Context in Which It Occurs
Automated agriculture equipment adoption	Farmers recalled initially adopting automated technology to address operator fatigue and to increase precision and efficiency
Misaligned expectations	Interviewees report a misalignment between expectations at technology adoption and the realities experienced in the field
Challenges experienced with using automated agriculture technology	Reoccurring challenges include: • Automated technology engaging or disengaging unexpectedly • Losing cellular and/or satellite signal • Faulty guidance system technology • Challenges with systems learning technology and feedback loops • Obstacle detection
Perceptions of autonomous vehicles on public roads	Farmers' experience with highly automated technology cautions their expectations of autonomous vehicles

Farmers' Experience with Automated Technology

Reasons for Adoption

Interviewees who work as agriculture producers were asked to recall why they initially started using automated agriculture equipment. Each of the growers in this study mentioned mitigating driver fatigue as a primary motivation for adopting automated technologies. As one interviewee recalled, "It was a time saver and it was a stress reliever. It made things a little easier through the day." Another interviewee mentioned that they sought to minimize operator fatigue to increase precision and efficiency:

> You can run longer hours with less fatigue. Operator fatigue used to be a bigger issue than it is now. I think you can pay more attention to the field operation that you are actually doing. Like if you are planting—you used to concentrate on driving straight…and concentrating on the front of your tractor and keeping it straight down the row, and now you can monitor what is going on behind you better; make sure the planter is doing what it is supposed to do.

Participants repeatedly mentioned that prior to early automated agriculture equipment, farmers had to estimate many variables such as amount of product to dispense based on factors including speed and width of the agriculture equipment. Adopting automated systems increased the precision of this process: "it took some of the guess work out of it and made it more precise."

Interviewees also mentioned that automated technologies initially appealed to them when they sought to make use of new farming techniques. As one interviewee recalled, “I was just looking to do some variable rate things in the field.”

Several farmers mentioned that widespread labor shortages in the agriculture industry led them to seek out new technologies that would improve the efficiency of their operations. This sentiment was shared by the 3 interviewees working in agriculture technology development who all mentioned that their respective companies’ efforts in developing new technologies is directly in response to the agriculture industry’s labor shortage and farmers’ demands for being able to—as one interviewee stated--“do more with less”.

Misaligned Expectations

One important theme that emerged in the findings of this research is that farmers report a misalignment between expected performance at adoption and realities in the field post-adoption. One interviewee mentioned the autosteering technology is not without unforeseen limitations:

> I had high expectations of it being ultra precise…it does well but it’s probably not quite how like I imagined. And I guess disappointment might be once in a while it will lose signal or sometimes it struggles to find its way. If I have two lines in the field, sometimes it doesn’t know which line to lock onto. And it can be a bit of a thrill ride if you’re sitting there and suddenly it decides to go a different direction.

Similarly, another interviewee reported expecting certain results when adopting the technology that were not actualized once using the new systems:

> You need to learn the limits of the equipment in order to be able to use it. Because a lot of times you’ll go ‘oh yeah we just dropped 25 grand on this thing, it ought to fix me pancakes and coffee at the same time. But it’s like ‘no’… My first perceptions were ‘oh this is going to be great; we’ll be able to turn it on and let it go’ and they are becoming more matched to the capabilities.

Many interviewees shared the sentiment that they had certain expectations for the technology at adoption that were misaligned with the realities in the field. According to the interviewees, the misalignment is often a result of the challenges they experience in using the technology as elaborated upon in the following section. However, not all misaligned expectations reported by interviewees cast a negative view. Several interviewees also reported that after adopting and using new agriculture technologies, they experienced positive unforeseen benefits.

As one farmer stated, “I think there are more benefits to it that I didn’t see when I first was thinking about getting and investing in this technology. I wasn’t sure if it would ever be worth the cost. But I think once you have it, it’s more beneficial than you realize it would be.” Interviewees who reported unexpected benefits mentioned that there were nuances in the technology that enabled them to be more precise and efficient with farming in ways they did not expect.

Challenges Experienced with Automated Technology

One of the primary themes in the data is that interviewees report common challenges with using the automated technology. The challenges they experience lead them to concerns with fully trusting more advanced technologies. The five primary challenges reoccurring in the data are discussed below.

1. Automated Technology Engaging or Disengaging Unexpectedly

Interviewees report automated systems unexpectedly engaging or disengaging while in operation. Recalling their experience with automated steering technology, one grower said, “I have had the automation shut off unexpectedly…and the tractor veers off course.” Another interviewee described similar occurrences:

> I have had it (Autosteer) where it switched off rather suddenly. My reaction after a few words that should not be said in public are usually an emergency stop; you slam on the clutch and hit the brakes and then you try to figure out what happened. You know we’re never going very quick; 4-5 miles per hour and suddenly it disengages and all of a sudden you’re kind of just drifting off to one side or the other.

2. Losing Cellular and/or Satellite Signal

A majority of interviewees reported losing cellular and/or satellite signal, often in rural areas, operating near hills, or in times of inclimate weather. According to interviewees, when this occurs, operations cease until resolved. In some cases, losing signal has caused extended delays. As this interviewee described it, “Cellular works for the most part unless you get into some low areas or behind hills. Satellite works for the most part except if the satellite goes down, which we have had happen before…And nothing runs if satellite goes down.”

Because automated technology has shifted how farmers conduct field operations and is fully dependent on the automation working, losing signal can result in significant challenges:

> There's always those frustrations—the days where you lose your satellite signal and you just have to stop because we've removed the planting markers that we used to use to make the mark on the ground to follow. Now, we're completely dependent on the autosteer so when some things go down, it's frustrating.

3. Faulty Guidance System Technology

A common challenge reported by interviewees are errors in the automated guidance system that lead operators in an undesired direction when operating machinery. In describing their experience using automated equipment, one interviewee stated that guidance systems which rely on a "GPS system alone to determine forward or reverse…can sometimes get confused as to which direction you are going. So you can turn around at the end of the field, think you're going in reverse and then you have hit the button to acquire the line and then it turns the exact opposite direction that it should be because it thinks it is going backwards when it is actually going forwards." Another grower described a similar situation, "It will maybe overshoot the line that you are trying to acquire or it might acquire a line that you weren't expecting it to. You thought it was going to steer in one position but all of a sudden it steers the other way. The machine itself can also get confused as to which direction it's traveling."

4. Issues with Systems Learning Technology and Feedback Loops

According to interviewees, an inability to receive feedback limits the sophistication and accuracy of the technology. For example, one grower stated, "The automated technology is getting better but they don't yet have the ability to learn and they are not a whole lot different than a high school kid in some cases…there often isn't a feedback loop for some of the things that need to be done."

This becomes more complicated when common actions of farmers are excluded from the technology's system programing. Referring to their experience working with farmers in Nebraska, the Product Training Specialist stated:

> Here in Nebraska, you have long enough rows in your fields that the combine can't make it all of the way through and the grain cart has to move over…and pull up next to the

> combine anyway…It's not reasonable for it to back up out of the field and unload and go forward again. So the grain cart just has to move over and drive over this corn that hasn't been harvested. Well, the SmartAg system was smart enough to know it wasn't supposed to drive over unharvested corn and so it wouldn't do it. There are a lot of things that farmers do that are not necessarily standard operating procedures. I'm not saying that it is unsafe, but something like that isn't something that you would program into a system but it is something that every farmer with long rows does at some point or another."

5. Obstacle Detection

The inability for existing automated technologies to detect and respond to certain obstacles is a primary concern for many interviewees. For example, recalling their own experience in the field, one grower mentioned, "There's always issues in the field—you could come across a washout or a hole that you need to avoid. It may not show up on a map, or it wasn't there last year so the vehicle doesn't know it's there." The software engineer working for an automated agriculture equipment company described obstacle detection as one of the greatest limitations of automated and autonomous agriculture technology: "Where the system breaks down is the perception and identification of obstacles."

As each of the five areas described above encapsulates, the challenges interviewees experience in using automated technology result in serious, and sometimes consequential, implications for farming. The systems engineer for an agriculture technology company discussed the challenges with designing technology that accurately reflects the intricacies of farmers' actions:

> There's a lot of things that you don't really think about that the operator or someone in the cab just monitors and occasionally adapts to. If something was controlling the machine it would have no idea that something was going wrong even through all of the sensors and everything reads okay.

For farmers, the challenges they experience in the field using automated technology often leads to trust issues with the prospect of using more fully advanced agriculture technologies. For example, one interviewee mentioned that their previous instances of the autosteer technology disengaging unexpectedly has "led to part of [their] lack of trust". When asked whether they would trust new technologies in agriculture, one interviewee replied "I would still be hesitant. Maybe I'm just kind of a control freak, but I like to still be in control of the vehicle if I need to be and I like to see what's going on in the field." For this interviewee, their experience with occasionally malfunctioning technology cautions their trust of fully autonomous agriculture equipment. Interviewees experiences with automated agriculture equipment and the challenges they have endured also greatly informs their perceptions of autonomous technology and their concerns about the ability for autonomous vehicles to safely operate on the diversity of conditions on public roads.

Farmers' Perceptions of Autonomous Technology

Interviewees were asked a series of questions surrounding their attitudes toward adopting new technologies in agriculture. Interviewees expressed interest, but also cautioned that based on their experience with existing technology, premature adoption of new technologies could be detrimental. As one grower posited:

> We understand that it is a great technology and takes a lot of stress off us as operators, but by the same token, it's not quite ready for prime time. There are limitations and if you don't understand those limitations, you're going to get in a lot of trouble really quickly.

Public Roads

Farmers are particularly attuned to navigating varying road conditions, and a majority of interviewees expressed concern with the ability for fully autonomous vehicles to perform on them. Based on their experience with agriculture technology malfunctioning, one interviewee imagined the challenges of an autonomous vehicle enduring similar challenges:

> What I have found out with technology is that it is not fail safe and it does have its limitations. And when it does break, it's usually something that the lay person can't fix. It takes a technician. And that's where I would have some concerns [with AVs] if someone gets stranded on the side of the road because their autonomous vehicle won't drive or if their autonomous vehicle errs and drives off the road, how would they correct it?

Rural roads in particular are prone to variable conditions and less maintained roads. One farmer who operates fields in rural areas questioned,

> Especially in rural areas, how will autonomous cars be able to detect the edge of the road? How would they be able to pass farm equipment? What would an autonomous vehicle do around manually driven farm machinery? I guess if I think of myself and an

> manually driven tractor, it might be less predictable what an autonomous car would do around me than what a car would do.

Another interviewee expressed similar concerns:

> I wouldn’t be confident that whatever software that is in the autonomous car would [safely navigate rural areas]…The main thing I think about when I think about autonomous cars are: ‘How will it handle gravel roads?’ because you don’t use the whole gravel road because a lot of times the shoulder is really soft and you could get sucked into the ditch. So it might look like the whole road is available for you to drive on but you can’t do that. And on really muddy roads, how does the autonomous vehicle know what speed it’s supposed to drive at? Because there are a lot of times where the posted speed is not the speed that you should be driving at because it’s not safe. And that goes for icy roads and muddy roads. And then obstacle avoidance. There are a lot of times where things end up in the middle of the road.

Lastly, interviewees described the importance of symbolic interactions and gestures to communicate between the agriculture equipment operator and motorists to safely navigate encounters on public roads. As one example, farmers mentioned that when they are operating agriculture machinery on public roads, they often position themselves toward the left of the driving lane—rather than the center—to signal to motorists when it is unsafe to pass. Interviewees repeatedly expressed concern that autonomous vehicles will not be able to engage in such situations which could lead to uncertainty and/or potentially unsafe encounters.

Discussion

This research demonstrates that the agriculture industry’s extensive experience with automated equipment offers novel insights for better understanding AV adoption and diffusion in the United States. We find that farmers describe automated agriculture technologies as a primarily positive asset to their work despite the various challenges they experience in using the technology. However, farmers also recognize that the relatively controlled environment of an agriculture field differs from the complexity of a public roadway. This recognition and the challenges they have experienced in the controlled environment, leads them to think critically about the capabilities of AVs. As one interviewee remarked:

> I’ve seen the good and the bad of what advanced technologies can do. Automated equipment has made farming easier and better, but things definitely go wrong. So as for autonomous vehicles, we hear a lot about the good things autonomous vehicles can do, but we need to be talking more about what could go wrong.

Farmers in this study repeatedly expressed significant concerns over the capabilities of autonomous vehicles, particularly their performance on rural roads. This finding challenges existing literature on technology adoption and diffusion, which presumes that prior experience with technology leads to more favorable perceptions of future technologies. This important finding suggests that driver experience with partially autonomous vehicles cannot be assumed to lead to eager adoption of fully autonomous vehicles. Farmers in this study were asked if they would adopt fully autonomous agriculture equipment, and a large majority of interviewees were hesitant to say they would adopt fully autonomous agriculture equipment.

Applying additional lessons learned from the agricultural industry's experience with automated farm equipment to the future of autonomous vehicles offers several implications for technology development, infrastructure, users, and public policy. These implications are summarized in *Table 2* below.

Table 2: Implications for on-road autonomous vehicles					
Theme	Context	Technology Implications	Infrastructure Implications	User Implications	Policy Implications
Technology Adoption	Farmers recalled initially adopting automated technology to address operator fatigue and to increase precision and efficiency	• Underscores need for complete autonomy and precision operation	• May be significant if embedded roadway technology is needed to ensure high autonomy and safety	• Expectations are high • Potential for AV technology early adoption is greatest in sectors where driver fatigue is a concern	• Reduced vehicle driver fatigue may increase roadway safety • Changes to labor markets (e.g., trucking and delivery) may impact need/desire for technology
Misaligned Expectations	Interviewees report a misalignment between expectations at technology adoption and the realities experienced in the field	• Expectations are high and there is very little margin for error.	• May be significant if embedded roadway technology is needed to ensure high autonomy and safety	• Expectations are high • Regardless of actual technological capabilities, users will likely push limits • Concerns regarding how human drivers (or other road users) will interact with AVs	• Proactive policies will be needed to ensure technologies meet or exceed expectations
Challenges with the Technology	Reoccurring challenges include: • Automated technology engaging or disengaging unexpectedly • Losing cellular and/or satellite signal • Faulty guidance system technology • Challenges with systems learning technology and feedback loops • Obstacle detection	• Expectations are high and there is very little margin for error. • Connectivity is a problem that is likely worse outside of cities	• May be significant if embedded roadway technology is needed to ensure high autonomy and safety • Underscores importance of nationwide cellular/satellite coverage • Enhanced safety investments (e.g., barriers) may be needed if technology is limited.	• Expectations are high • Trial users and early-adopters may compensate (and potentially hide) technology limitations • Concerns regarding how human drivers (or other road users) will interact with AVs	• Proactive policies will be needed to ensure technologies meet or exceed expectations • Proactive infrastructure policies are likely necessary to facilitate connectivity
Perception of the Technology	Farmers' experience with highly automated technology cautions their expectations of autonomous vehicles	• AVs must be equipped to handle a diversity of road conditions • AVs must handle diverse responses from human drivers (and other road users)	• Infrastructure maintenance will be imperative • Concerns regarding existing roadway conditions, particularly in rural areas	• Concerns regarding how human drivers (or other road users) will interact with AVs	• Policy is needed to address the wide range of potential interactions between AVs and human road users

Technology Implications

This study found that farmers recalled initially adopting automated technology to increase precision and efficiency in agriculture operations. However, upon using the technology, farmers reported a wide range of technological challenges. For AV technology development, this reinforces the importance of thorough testing in a diversity of real-world scenarios that achieves complete precision before the technology becomes commercially available. The challenges discussed in this research unique to rural areas emphasizes the differing road conditions and that AV technology must be designed to ensure success across spatial and geographic differences. Lastly, AV technology must recognize and take into account that motorists and other road users often use symbolic interactions and gestures to safely navigate public roadways.

Infrastructure Implications

The challenges farmers reported in this research underscores the importance of nationwide cellular and satellite coverage. In this study, farmers repeatedly discussed the limitations of rural roadways, including lack of signage and road markings, narrow and/or gravel roads, and poor maintenance. If we assume that AVs will require consistent roadway conditions to operate safely then transportation agencies should be particularly aware of the potential increased costs. For example, even a simple requirement like consistent paving material or lane and shoulder markings to ensure AVs can sense the roadway could be extremely costly (and likely cost-prohibitive, particularly in rural areas). Furthermore, it is unlikely that all traffic accidents could be avoided, even assuming a fully-autonomous fleet, raising the question of whether existing highway safety measures will be adequate (particularly if AVs are likely to be traveling at higher speeds).

User Implications

One of the primary reasons participants in this study reported initially adopting automated agriculture technologies was to address operator fatigue. All participants in this study agreed that they saw improvements to operator fatigue upon adoption and that it continues as one of the primary benefits of automated agriculture technologies for their work. This suggests that early adopters of AV technology have great potential in sectors where driver fatigue is a concern.

This study also revealed that farmers often had misaligned expectations of the automated technologies; that is, their expectations for the technology at adoption differed from what they later experienced in the field. This suggests that one should not over-emphasize the speculative perceptions of those with no experience using the technology. Additionally, decision-makers should be aware that AV trial users and early-adopters may not fully experience technology limitations; there is also potential for such groups to compensate or camouflage limitations.

Public Policy Implications

The prospect of AVs reducing driver fatigue holds potential for increasing roadway safety. Findings from this study emphasize the importance for proactive policies that ensure technologies meet (or exceed) expectations. Other proactive policies facilitating infrastructure connectivity and addressing the wide range of potential interactions between AVs and human drivers will also be needed.

Conclusion

By focusing on the experiences of those who have participated in the decision-making calculus of new automated technologies--rather than focusing exclusively on early speculative perceptions with inexperienced populations--this study offers a more holistic scope to understanding AV adoption decisions. Automated agriculture technology has played an important part in American agriculture for the last two decades. Learning from the experiences of those in the agriculture industry also produced relevant findings with important technology, infrastructure, user, and policy implications for on-road autonomous vehicles.

Although this study population was limited to the Midwestern United States, the findings of this research offer insight to better understand potential AV adoption. Additionally, this research made experience with automated farming technology a criterion for inclusion in the study, and therefore, does not include any potential farmers who have rejected all forms of automated machinery. However, this group is likely very small given the pervasiveness of automated technology use in American agriculture over the last two decades. Future research may benefit from further exploring the experiences of farmers who initially rejected automated technologies, but later chose to adopt. Findings from this research illuminate concerns over the ability for AVs to successfully perform on rural and/or gravel roads. Future research is warranted to examine the financial implications of increased roadway infrastructure and maintenance for transportation agencies.

Farmers' experience with automated farm equipment offers a cautionary tale for the development of AVs. Unforeseen circumstances are likely to arise as AVs become more widespread and encounter a growing diversity of scenarios. The findings and implications of this study offer salient relevance for AV technology developers, users, and policy decision-makers as they work toward an autonomous future. This research reiterates that the stakes are high and there is little room for error; therefore, technology developers must ensure precision in AV performance. Users should recognize that expectations for AVs at adoption will likely differ from their experience in reality. For policymakers, this research echoes the need to create anticipatory and adaptable policies for advanced transportation technologies. By thinking carefully and critically about AVs, the prospect of a safe fully autonomous fleet inches closer to fruition.

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SECTION 2

Potential Implications of Autonomous Vehicles: A Survey of Nebraskans

Introduction

Preparing Nebraska for a future with autonomous vehicles (AVs) requires first understanding the current mobility-related challenges in Nebraska which might be addressed with the adoption of AVs. Utilizing a statewide survey, this study aims to better identify what challenges related to access and mobility currently exist in the state. Further, this study begins to imagine how AVs might address such issues in Nebraska. In examining areas of need as well as Nebraskans' perceptions of AVs, this study explores both the challenges and opportunities AVs present for Nebraska. The study concludes with a discussion of the implications for those working to bring AVs to fruition in Nebraska.

Literature Review

Transportation Challenges for an Aging Population

Within the coming decades, adults over 65 in age are expected to outnumber children in the United States [1]. The aging population in Nebraska is growing in every county, and the statewide population of residents age 65 and over is expected to increase nearly 70% between 2010 and 2030 [2]. In a society where mobility, particularly auto-mobility, is closely tied to individual freedom, as adults age and cease driving, they are more likely to have unmet travel needs and experience feelings of social isolation [3]. Driving cessation among older adults is influenced by a variety of social factors including personal identities such as race and gender, as well as availability of social support networks who provide transportation [4, 5, 6]. One Finnish Study found that women tend to stop driving while they are younger and in better health than their male peers, which can lead to unmet transportation needs and/or feelings of social isolation [7]. This becomes compounded for aging adults living in rural areas where access to public transit services and other mobility options are often more limited [8, 9]. Transportation and mobility access for aging adults is a widespread challenge, of which Nebraska is not immune. A recent estimate reveals that 17,000 households in Nebraska headed by a person age 65 or older have no vehicle access [10]. Autonomous vehicles are touted as a potential mobility solution for aging adults with limited mobility [11].

Health Care Access and Transportation

Transportation and mobility precede the ability to access healthcare. Transportation is a barrier to accessing healthcare and contributes to an inability to seek preventative care, rescheduled, and missed appointments, delayed care, and delayed/missed prescription medication used [12]. Groups with some of the most significant transportation barriers to accessing healthcare such as aging populations, poor communities, and racial/ethnic minorities also experience disproportionate health outcomes and disparities. One comprehensive 2020 study found that in 2017, 5.8 million people in the United States delayed or forwent medical treatment due to a lack of transportation [13].

Food Access and Transportation

Given our reliance on the automobile, our ability to access food is often dependent on our access to a vehicle. Distance to grocery stores, and the availability of stores that stock healthy foods only exacerbates this problem, leading to 'food deserts' in both urban and rural communities [14]. For urban residents, food deserts are typically associated with underserved and low-income communities in which grocers are either unable (due to zoning and/or financing) or unwilling to locate [15]. For rural residents, many small town grocers have closed in recent years, and larger retailers serve vast areas [16]. In these cases, the problem is distance is often the primary factor hindering food access. For both urban and rural residents, a short-term solution (i.e., short of land-use and policy approaches to address food deserts), autonomous vehicles may increase transportation access, thereby increasing food access.

Roadway Safety

There is an ongoing epidemic of fatalities on US roads. There are over 35,000 fatalities and 2 million injuries on U.S. roads annually in the United States [17]. One of the primary selling-points for autonomous vehicles is their ability to operate safely and dramatically reduce on-road fatalities. But roadway safety improvements are dependent on technology uptake; that is, if people are unwilling to ride in autonomous vehicles, and uptake is low, then there may only be limited safety improvements. Safety improvements also depend on where autonomous vehicles are deployed. There is also a spatial dimension to safety, and while crashes are rare in rural areas, they tend to be more deadly in urban ones, and highway travel is more deadly than city travel (even though crash rates may be higher in urban areas).

Latent Travel Demand

Latent (or induced) demand has plagued the US transportation system since it's inception. As we build auto infrastructure to meet increasing VMT levels, that same infrastructure in turn induces additional travel by car [18]. It is then also reasonable to assume that any technological innovations that make driving an increasingly attractive option for different types of travel, will in turn induce increased demand. Existing literature supports this assertion, with one study finding an over 80% increase in VMT when individuals have access to a "self-driving" (in this case, a car with a chauffeur) vehicle [19]. Latent demand in Nebraska could occur in urban areas in the form of additional short trips, or in rural areas as long-distance recreational travel that is either induced by technology access or as a substitute for other modes (e.g., air travel). Latent demand may also spur individuals to move to more rural locations, or accept jobs in more distant locations, as long-distance travel could become easier and safer thanks to vehicle autonomy [20].

Methodology

This research uses a survey methodology to answer the following research questions:

1) How do Nebraskans perceive autonomous vehicles?
2) How might autonomous vehicles address specific areas of need for Nebraskans?

Questionnaire Design

The survey design, topics, and questions were informed by themes and issues which emerged during Part 1 of this research as well as a review of the existing literature. The survey questions were drafted in partnership with the lead investigator, a doctoral student graduate research assistant, and the University of Nebraska's Bureau of Sociological Research (BOSR) which is a small team of well-trained research experts. The eight-page paper survey consisted of substantive questions about transportation issues, transportation needs, and demographic questions about the respondent and their household. The survey was in English only. A copy of the questionnaire can be found in the Appendix. BOSR administered the survey and began the data analysis process by inputting the raw data into technological software used for analysis. BOSR provided a written report of their methodology used which is provided in the sections below.

Sampling Design

The survey focused on Nebraska households stratified into three groups: urban large, urban small, and rural. In total, the sample design included three strata. The counties included in each strata can be found in the Appendix.

The sample for the survey was purchased from Dynata. A total of 2,000 cases were provided to BOSR by Dynata on January 30, 2020. In total for each strata, urban large contained n=500; urban small contained n=500; and rural population contained n=1,000.

Data Collection Process

The data collection process involved three mailings. In the initial contact, a survey packet was mailed to each household. This packet included a cover letter explaining the survey, a copy of the survey, and a postage pre-paid addressed business reply envelope for the survey to be mailed back to BOSR. The first mailing was mailed March 5, 2020. For each address, the adult age 19 or older of that household who would have the next birthday after February 1, 2020 was asked to complete the questionnaire. One week after the first mailing, all households were mailed a postcard reminding them to complete the survey. This reminder postcard was sent on March 12, 2020. The final mail survey package was set out on March 26, 2020. All communication materials were in English only.

Response Rate

In total, 612 surveys were completed or partially completed by the end of the field period on May 26, 2020. The response rate of 30.6% was calculated using the American Association for Public Opinion Research's (AAPOR) standard definition for Response Rate 2. Of the 2,000 addresses sampled, 8.2% (n=164) were determined to be ineligible (e.g., no such addresses; vacant) and 3.9% (n=78) were undeliverable addresses with unknown eligibility. Refusals (e.g., blank survey returned; letter, phone call, or e-mail stating refusal to participate) and refused mail were obtained from 1.3% (n=26) of the sample.

Data Processing

Mail survey data were entered using Epi Info 6 software with data saved on BOSR's secure networked file server. Data entry was completed by experienced data-entry staff. All of the data-entry workers had previous experience in data entry using Epi Info 6 on other mail survey projects. The data-entry staff was supervised by full-time BOSR project staff.

Data entry was completed in two steps. First, one data-entry worker would enter responses from a single survey. Second, another data-entry worker would re-key the survey and be alerted to any discrepancies with the first entry. Supervisory staff members were available to answer questions about discrepancies or illegible responses.

Data Cleaning

The data were recorded and stored on a secure server located within the Sociology Department at UNL. The Statistical Package for the Social Sciences (SPSS) software package was used to process and document the dataset. The dataset was exported from Epi Info 6 into an SPSS system file. BOSR removed any cases that were duplicate or blank. The first step in data cleaning was to run frequency distributions on each of the variables in the survey. The second step was to generate variable and value labels. The final step in data cleaning was to check for out-of-range values on all survey items. Recoding was done to correct for the most obvious errors/inconsistencies in the data.

Data Weights

The data were weighted to account for the within-household probability of selection and population characteristics. First, data were weighted by the number of adults living in the household (Hwat) in order to adjust for within-household selection probability. Then, post stratification weights were applied based on age and gender in order for the data to more closely resemble the population.

Data Analysis

The weighted data was analyzed using SPSS software. Using SPSS, descriptive statistics for each topic were generated and analyzed for trends. The results are reported in the following section.

Findings

As the findings below discuss, Nebraskans view AVs cautiously and at times negatively. Despite their views of autonomous vehicles, the survey revealed several areas of need for

Nebraskans which might be addressed with AVs. The findings below are organized around themes and corresponding questions to the survey. The descriptive statistics for each theme are presented below and inferences about the implications of each will be explored in the following discussion section.

Healthcare

Access to Healthcare

The survey questions pertaining to accessing healthcare concern mode of transportation used and how frequently survey respondents access healthcare facilities. The majority of respondents travel fewer than 30 minutes to access their primary care physician. 74.2% of respondents access a healthcare facility less than once per month; 16.1% do so 1-3 times per month; 1.9% do so 4-8 times per month; 2.5% do so 3 or more times per week; and 3.6% of respondents state they never access healthcare facilities. The vast majority of respondents (87.8%) reported driving themselves to healthcare facilities.

Table 1: Traveling to Healthcare

	Mean	Median
Travel minutes to primary care physician	2.24	2.00

Table 2: Access to Healthcare

	Never	< 1x per month	1-3x per month	4-8x per month	> 3x per week	Total
Frequency in accessing healthcare facilities	22	454	99	12	15	602
Percentage	3.7%	75.5%	16.4%	2.0%	2.5%	100.00%

Table 3: Transportation Modes Used to Access Healthcare

	Public transit / Van service	Taxi / Ridesharing	Drive oneself	Driven by friend/family	Walk	Bike	Other	Total
Transportation Mode	8	9	537	23	3	0	8	589
Percentage	1.4%	1.6%	91.2%	3.9%	.5%	0%	1.4%	100.0%

Further analysis examined socio-economic variables in relation to mode of transportation for healthcare trips. Although only a small percentage of participants reported primarily using public transit to access healthcare, public transit is increasingly critical for marginalized groups. 57.1% of respondents who reported using public transit to access healthcare reported an annual household family income of under $24,999. Meanwhile, 12.1% of respondents who reported driving themselves to access healthcare reported an annual household family income of under $24,999. The ages of respondents who rely on public transit to access healthcare range from 49 to 90 with an average of 63.

Attitudes Around Access to Healthcare

In the section on healthcare, the survey also inquired about various attitudes pertaining to experiences in accessing healthcare. Table 4 below summarizes the findings. 45.3% of respondents agreed or strongly agreed with the statement: *It is important how close I live to my primary care doctor/physician's office/healthcare facility;* only 17.2% disagreed or strongly disagreed, and 37.6% stated no preference. The cost of transportation reportedly has little influence on how often respondents visit their doctor. Only 2.5% stated the cost of transportation influences their decision on how often to visit their doctor. When asked whether they would like prescription medications to be delivered to their home, 38.5% agreed; 26.3% disagreed; 35.2% had no preference.

Table 4: Attitudes Around Access to Healthcare

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
It is important how close I live to my healthcare facility	37	235	226	83	21	601
	6.2%	39.1%	37.6%	13.8%	3.4%	100.0%
There are times where I am not able to get an appointment with my doctor as quickly as I would like	41	168	124	197	70	600
	6.9%	28.1%	20.6%	32.7%	11.7%	100.0%
The cost of transportation influences how often I visit my doctor	9	5	72	189	322	598
	1.6%	.9%	12.1%	31.6%	53.9%	100.0%
I wish it was easier to get to	18	57	207	168	149	599

my doctor/healthcare facility	3.1%	9.5%	34.6%	28.1%	24.8%	100.0%
I would like my prescription medications to be delivered to me at home	68	162	211	99	59	599
	11.4%	27.1%	35.2%	16.5%	9.8%	100.0%

Traveling by Driverless Car

Travel & Workplace

The survey questions pertaining to travel patterns were designed to gain an understanding of how AVs might impact work commutes in Nebraska as well as regional travel demand. Participants were divided on their stated willingness to live further away from their workplace; 27.4% stated they were either very or somewhat willing to live further away; 42.4% stated they were unwilling or very unwilling; 30.3% had no preference.

Table 5: Summary of Work Travel Patterns with an AV

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
How willing would you be to live further away from your workplace if you could get to work with a driverless vehicle?	50	113	180	138	113	594
	8.4%	19.0%	30.3%	23.3%	19.1%	100.0%

Regional Travel Demand

The survey questions focused on investigating regional travel demand asked about experiences and preferences in accessing other places that are a 3-10 hour drive from their location in Nebraska (such as Denver, Chicago, and Minneapolis). When traveling regionally, the majority reported usually driving (68.4%) and 25.0% reported flying in an airplane. The majority (59.6%) stated there are regional places they would like to travel to more often. When participants were asked about their preferences between using an AV versus driving themselves and using an AV versus flying, in both scenarios, the majority of participants stated they would prefer the alternative to using an AV.

Table 6: Regional Travel Demand: Mode of Travel

	Car	Airplane	Train	Bus	Other	Total
Mode of travel for regional trips	380	139	0	12	24	555
	68.4%	25.0%	0%	2.2%	4.3%	100.0%

Table 7: Regional Travel Demand: Attitudes

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
There are cities/places that are a 3-10 hour drive that I would like to go to more often	146	209	173	59	12	599
	24.7%	34.9%	28.9%	9.8%	2.0%	100.0%
I would prefer to use a driverless vehicle or selfdriving car instead of flying to cities/places that are a 3-10 hour drive from where I live	60	105	161	145	127	598
	10.0%	17.6%	26.9%	24.2%	21.2%	100.0%
I would prefer to use a driverless vehicle or selfdriving car instead of driving to cities/places that are a 3-10 hour drive from where I live	61	113	172	147	104	597
	10.2%	18.9%	28.8%	24.6%	17.4%	100.0%

Sharing the Road with Driverless Vehicles

Survey participants were asked a series of questions surrounding their attitudes around potentially sharing the road with AVs. 33.1% of survey respondents stated they either agree or strongly agree with the statement *I am comfortable with sharing the road with driverless cars;* 51.9% disagreed and 15.2% stated no preference. 29.1% of respondents reported that they would prefer to share the road with AVs than with human drivers. Meanwhile, 46.9% stated they would not prefer to share the road with AVs rather than human drivers. 23.8% had no preference. When asked about their current comfort in sharing the road with autonomous trucks, only 24.8% agreed or strongly agreed that they are comfortable; 61.5% disagreed or strongly disagreed that they are comfortable sharing the road with autonomous trucks; 13.8% had no preference. Lastly, when asked if they would prefer large trucks to be autonomous instead of driven by human drivers, only 14% agreed or strongly agreed; 65% disagreed or strongly disagreed; 21% had no stated preference.

Table 8: Sharing the Road with Driverless Vehicles

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
I am comfortable with sharing the road with driverless cars	59	139	91	173	137	598
	9.9%	23.2%	15.2%	29.0%	22.9%	100.0%
I would prefer sharing the road with driverless cars than with human drivers	57	118	143	163	119	601
	9.5%	19.6%	23.8%	27.1%	19.8%	100.0%
I am comfortable with sharing the road with driverless trucks	32	117	83	150	219	600
	5.3%	19.5%	13.8%	25.0%	36.5%	100.0%
I would prefer if large trucks were driverless instead of driven by human drivers	27	57	126	165	225	600
	4.5%	9.5%	21.0%	27.5%	37.5%	100.0%

Trust in Autonomous Vehicles

Survey participants were asked a sequence of questions to gain a sense of the degree to which they trust autonomous vehicles. 37% of survey respondents reported that they strongly trust or trust AVs will be safe; 40.9% distrust or strongly distrust; and 22.1% stated no preference. When asked whether they trust autonomous vehicles will safer than human drivers, 28.6% agreed or strongly agreed; 38.7% stated they distrust or strongly distrust, and 32.8% stated no preference. Survey respondents stated they have very little trust in the ability of AVs to handle winter road conditions in Nebraska. 10.7% said they trust or strongly trust AVs to handle winter road conditions in Nebraska; 67.8% stated they distrust or strongly distrust; and 21.8% stated no preference. When asked if they would trust AVs more than human drivers during winter road conditions, 13.6% stated they trust or strongly trust AVs; 56.0% stated they would distrust or strongly distrust; and 30.2% stated no preference.

Table 9: Trust in Autonomous Vehicles

	Strongly trust	Trust	Neither trust nor distrust	Distrust	Strongly distrust	Total
	31	191	133	148	98	601

I trust driverless cars will be safe (in general)						
	5.2%	31.8%	22.1%	24.6%	16.3%	100.0%
I trust driverless cars will be safer than human drivers	38	134	197	130	102	600
	6.3%	22.3%	32.8%	21.7%	17.0%	100.0%
I trust driverless cars to handle winter road conditions in Nebraska	1	63	131	199	207	601
	.17%	10.5%	21.8%	33.4%	34.4%	100.0%
I trust driverless cars more than human drivers in winter road conditions in Nebraska	8	74	181	156	180	600
	1.3%	12.3%	30.2%	26.0%	30.0%	100.0%

Accessing Food

To gain a sense of food access in Nebraska and predict how AVs might address issues related to food access, survey participants were asked a series of questions pertaining to how they currently access food as well as their attitudes toward using autonomous services to access food. There is a wide range in responses to the calculated distance to *preferred* grocery store. The responses range from 0 miles to 143 miles. 60.4% stated that they live less than 3 miles from their preferred grocery store. When asked about the nearest grocery store to their home, the responses ranged from 0 miles to 30 miles. 46.3% stated they have a grocery store less than 1 mile from their home and 73.4% stated they have a grocery store less than 3 miles from their home. A majority of participants (63.6%) report accessing a grocery store 1-2 times per week on average. When asked about where participants *primarily* access food/groceries, 99.8% stated the grocery store; 30.5% stated convenience stores; 27.5% stated farmer's markets; 4.9% stated food pantry, 14.3% stated food delivery services, 7.1% stated meal-prep delivery services, 7.9% stated meal delivery services. 19.1% of respondents reported using a food delivery service within the last year; 11.6% reported using a meal-prep delivery service in the last year; and 19.5% reported using a meal delivery service within the last year.

Table 10: Distance to Grocery Stores

	Mean	Median
Distance in miles to preferred grocery store	7.88	3.00

Distance in miles to closest grocery store	3.65	2.00

Table 11: Frequency of Accessing Grocery Store

	Never	< 1x per month	1-3x per month	4-8x per month	> 3x per week	Total
Frequency of accessing grocery store	1	5	134	383	79	602
	.2%	.8%	22.3%	63.6%	13.1%	100.0%

Table 12: Accessing Food

	Yes	No	Total
Primarily access food via grocery store	601	1	602
	99.8%	.2%	100.0%
Primarily access food via convenience store (ex: gas station, corner market, etc.)	177	403	580
	30.5%	69.5%	100.0%
Primarily access food via farmers market	159	420	579
	27.5%	72.5%	13.8%
Primarily access food via food pantry	28	542	570
	4.9%	95.1%	100.0%
Primarily access food via food delivery services (ex: Amazon Pantry, Hy-Vee grocery delivery)	83	498	581
	14.3%	85.1%	100.0%
Primarily access food via meal prep delivery services (ex: Blue Apron, Hello Fresh)	41	538	579
	7.1%	92.9%	100.0%
Primarily access food via meal delivery services (ex: Meals on Wheels, GrubHub, UberEats)	46	536	582
	7.9%	92.1%	100.0%
Used a food delivery service in last year	115	488	603
	19.1%	80.9%	100.0%
	70	534	604

Used a meal-prep delivery service in last year	11.6%	88.4%	100.0%
Used a meal delivery service in last year	118	486	604
	19.5%	80.5%	100.0%

Further analysis was conducted to reveal differences in usage of meal and food delivery services by population strata. The table below includes the breakdown of the usage of food/mean delivery services by each of the three population strata (urban large, urban small, and rural). There is the greatest percentage of usage of each type of service in large urban areas, which is unsurprising given that access is likely greatest in larger urban areas.

Table 13: Usage of Meal and Food Delivery Services by Strata

	Urban Large	Urban Small	Rural
% respondents who used meal delivery service w/in last year (ex: GrubHub, UberEats)	25.8%	8.6%	8.2%
% respondents who used meal-prep delivery service w/in last year (ex: Blue Apron, Hello Fresh)	15.6%	2.9%	5.3%
% respondents who used a food delivery service w/in last year (ex: Amazon Pantry, HyVee Grocery)	20.4%	11.5%	12.0%

Participants were also asked a set of questions concerning their perceptions around accessing food. 5.2% of respondents agreed or strongly agreed with the statement *There are times that I would like to grocery shop, but am unable to do so because of transportation limitations.* 88% disagreed or strongly disagreed; and 7% stated no preference. 8.1% of participants reported going to a grocery store that is not their preferred grocery store because their preferred grocery store is difficult to access. 21.2% agreed or strongly agreed that they would use a driverless vehicle to access the grocery store; 54.6% disagreed or strongly disagreed that they would use a driverless vehicle to access the grocery store; and 24.2% stated they had no preference. Only 4.3% agreed or strongly agreed they would go to the grocery store more frequently if driverless vehicles were available; 80.6% disagreed or strongly disagreed; and 15.1% had no stated preference. Lastly, 7% stated they agreed or strongly agreed they would go to their preferred grocery store more often if driverless vehicles were available; 76.3% disagreed or strongly disagreed; and 16.6% had no stated preference.

Table 14: Perceptions Around Accessing Food

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
There are times that I would like to grocery shop, but am unable to do so because of transportation limitations	13	18	42	204	327	603
	2.2%	3.0%	7.0%	33.8%	54.2%	100.0%
I sometimes go to a grocery store that is not my preferred grocery store because my preferred grocery store is difficult to access	11	38	58	217	277	599
	1.8%	6.3%	9.7%	36.2%	46.2%	100.0%
I would use a driverless vehicle to get to and from the grocery store	40	88	146	147	182	603
	6.6%	14.6%	24.2%	24.4%	30.2%	100.0%
If driverless vehicles were available, I would go to the grocery store more frequently than I currently do	15	11	91	207	279	603
	2.5%	1.8%	15.1%	34.3%	46.3%	100.0%
If driverless vehicles were available, I would go to my preferred grocery store more frequently than I currently do	18	24	100	187	273	603
	3.0%	4.0%	16.6%	31.0%	45.3%	100.0%

Utilizing Public Transit and Ridesharing Services

Survey participants were asked a series of questions pertaining to their usage of and perceptions surrounding existing shared transportation modes such as public transportation and ridesharing services (ex: Lyft, Uber). A majority of respondents (57.5%) stated they feel safe using public transportation, and a majority of respondents (63%) further agreed that their feelings of safety on public transportation is a result of knowing that there is a bus or train operator on board. Only 20.5% of respondents stated that they would allow their children (under 18) to ride in a transit vehicle if there was no operator/driver present.

Table 15: Perceptions of Public Transit and Ridesharing Services

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree	Total
I feel safe using public transit	57	287	207	39	8	598
	9.5%	48.0%	34.6%	6.5%	1.3%	100.0%
Knowing that there is a bus or train operator on board helps me feel safe	67	300	190	24	4	585
	11.5%	51.3%	32.5%	4.1%	.7%	100.0%
I feel comfortable letting children (under 18) use public transit without a parent/guardian	9	80	255	167	95	576
	1.6%	13.9%	44.3%	29.0%	16.5%	100.0%
I would allow my children to ride on a driverless transit vehicle even if there was no bus or train operator/driver present	17	102	158	174	129	580
	2.9%	17.6%	27.2%	30.0%	22.2%	100.0%
My community would benefit from a driverless bus	33	113	236	107	95	584
	5.7%	19.3%	40.4%	18.3%	16.3%	100.0%
I feel safe using ridesharing services (Uber, Lyft)	41	256	196	69	27	589
	7.0%	43.5%	33.3%	11.7%	4.6%	100.0%
I have felt uncomfortable while using ride sharing services	16	89	274	136	62	577
	2.8%	15.4%	47.5%	23.6%	10.7%	100.0%
I feel safe letting my children	2	32	218	189	141	609

(under 18) use ridesharing without a parent/guardian	.3%	5.3%	35.8%	31.0%	23.2%	100.0%
I would feel safe using ride sharing services if they were driverless vehicles	32	160	180	136	85	593
	5.4%	27.0%	30.4%	22.9%	14.3%	100.0%
I would feel safe allowing my children to use ridesharing services if they were driverless vehicles without a parent/guardian present	3	89	157	188	149	586
	.5%	15.2%	26.8%	32.1%	25.4%	100.0%

Discussion & Conclusion

The findings from this study further understanding on the future of autonomous vehicles in Nebraska, particularly in two areas: 1) Assessing current public attitudes of AVs; and 2) Better understanding the role of AVs in addressing ongoing challenges facing the state of Nebraska. Overall, the survey findings suggest that many Nebraskans are slightly skeptical of AVs and hesitant to share the road with a driverless vehicle. The data from this study suggests that a significant shift in public opinion will likely be necessary in order for AVs to flourish in Nebraska. To best target strategies for educating the public about AVs, further research is necessary to better understand what specifically influences the public's opinion of AVs and how opinions change over time.

Delivering goods and services via AV technology may be a viable path toward shifting Nebraskans perceptions of AVs while also helping to address present needs related to mobility and access. This research points to opportunities for AV technology to aid in healthcare access such as telehealth and prescription medication delivery. Access to food and groceries in Nebraska may also be improved through AV technology.

Although AV technology holds great potential for Nebraska, this study also reveals challenges that should not be ignored. This study found that public transit operators contribute to feelings of personal safety and security when using public transit and the parental choice to allow minors to use public transit alone. This finding is important in light of conversations imagining shared autonomous vehicles and autonomous transit. Shared autonomous vehicles or autonomous transit services without agency personnel may compromise the feelings of safety for some and influence their decisions to use the service.

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APPENDIX
BOSR Methodology Report

Nebraska's Driverless Future
Survey Methodology Report

Prepared: June 2020

The contents of this report conform to our highest standards for data collection and reporting. If you should have any questions or concerns regarding the information reported within, please contact us.

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Contents

Introduction

This report presents a detailed account of the design of the 2020 Nebraska's Driverless Future Survey. The project was commissioned by researchers at the College of Architecture at the University of Nebraska-Lincoln (UNL) and administered by the Bureau of Sociological Research (BOSR). The purpose of this project is to examine transportation challenges for Americans aging-in-place, with implications for urban planning and so-called smart-city technologies. The work aims to understand and quantify age-related transportation challenges; specifically, a reduced or lost ability to drive, associated health and safety risks, and the burden this places on individuals, caregivers, and the community.

Sampling Design

The Driverless Future Survey focused on Nebraska households stratified into three groups: urban large, urban small and rural. In total, the sample design included three strata. The counties included in each strata can be found in Appendix D.

The sample for the Driverless Future Survey was purchased from Dynata. A total of 2,000 cases were provided to BOSR by Dynata on January 30, 2020.

Strata	n
Urban Large	500
Urban Small	500
Rural population	1,000
Total	2,000

Questionnaire Design

The survey questions were developed by the researcher and BOSR. This eight-page paper survey consisted of substantive questions centered on transportation use, opinions about transportation issues, transportation needs, and demographic questions about the respondent and their household. The survey was in English only. A copy of the questionnaire can be found in Appendix A.

Data Collection Process

The data collection process involved three mailings. In the initial contact, a survey packet was mailed to each household. This packet included a cover letter explaining the survey, a copy of the survey, and a postage pre-paid addressed business reply envelope for the survey to be mailed back to BOSR. The first mailing was mailed March 5, 2020. For each address, the adult age 19 or older of that household who would have the next birthday after February 1, 2020 was asked to complete the questionnaire. One week after the first mailing, all households were mailed a postcard reminding them to complete the survey. This reminder postcard was sent on March 12, 2020. This final mail survey package was sent out on March 26, 2020. All communication materials were in English only and can be found in Appendix B.

Response Rate

In total, 612 surveys were completed or partially completed by the end of the field period on May 26, 2020. The response rate of 30.6% was calculated using the American Association for Public Opinion Research's (AAPOR) standard definition for Response Rate 2. Of the 2,000 addresses sampled, 8.2% (n=164) were determined to be ineligible (e.g., no such address; vacant) and 3.9% (n=78) were undeliverable addresses with unknown eligibility. Refusals (e.g., blank survey returned; letter, phone call, or e-mail stating refusal to participate) and refused mail were obtained from 1.3% (n=26) of the sample.

Data Processing

Mail survey data were entered using Epi Info 6 software with data saved on BOSR's secure networked file server. Data entry was completed by experienced data-entry staff. All of the data-entry workers had previous experience in data entry using Epi Info 6 on other mail survey projects. The data-entry staff was supervised by full-time BOSR project staff.

Data entry was completed in two steps. First, one data-entry worker would enter responses from a single survey. Second, another data-entry worker would re-key the survey and be alerted to any discrepancies with the first entry. Supervisory staff members were available to answer questions about discrepancies or illegible responses. The data-entry staff is paid by the hour, not by the number of surveys entered. This method of payment is used so that we can ensure the high quality of the data collected by our staff.

Data Cleaning

The data were recorded and stored on a secure server located within the Sociology Department at UNL. The Statistical Package for the Social Sciences (SPSS) software package was used to process and document the dataset. The dataset was exported from Epi Info 6 into an SPSS system file. BOSR removed any cases that were duplicate or blank. The first step in data cleaning was to run frequency distributions on each of the variables in the survey. The second step was to generate variable and value labels. The final step in data cleaning was to check for out-of-range values on all survey items. Recoding was done to correct for the most obvious errors/inconsistencies in the data.

Data Weights

The data were weighted to account for the within-household probability of selection and population characteristics. First, data were weighted by the number of adults living in the household (Hwat) in order to adjust for within-household selection probability. Then, post stratification weights were applied based on age (age_grp) and gender (Q33A) in order for the data to more closely resemble the population. Tables 2 and 3 in Appendix C display 2010 Census population data and Nebraska's Driverless Future Survey data weighted and unweighted frequencies both with and without the design effect taken into account. The final weight in the dataset is called Pwate.

Design Effects

The design effect due to weighting adjustments is 2.83, which represents the loss in statistical efficiency that results from unequal weights[1].

Disproportionate stratification was used for the Driverless Future Survey, as discussed earlier. The use of this type of sampling resulted in a sampling design effect of 0.62[2].

Appropriate adjustments need to be incorporated into statistical tests when using the Nebraska's Driverless Future Survey data. See Estimate of Sampling Error in Appendix C.

Questions

Any questions regarding this report or the data collected can be directed to the Bureau of Sociological Research (BOSR) at the University of Nebraska-Lincoln by calling (402) 472-3672 or by sending an e-mail to bosr@unl.edu.

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[1] The formula used is: $1 + \mathrm{cv}^2(\mathrm{w}) = \frac{\mathrm{n}(\sum_1^{\mathrm{n}} \mathrm{w}_\mathrm{i}^2)}{(\sum_1^{\mathrm{n}} \mathrm{w}_\mathrm{i})^2}$

[2] The formula used is: $deff = \frac{\mathrm{var}_{complex}(\bar{y})}{\mathrm{var}_{SRS}(\bar{y})}$. Used Q29 (Have you utilized a food delivery service within the last year) to calculate.

Appendices

Appendix A: 2020 Nebraska's Driverless Future Survey

Healthcare

Driverless cars might help people access healthcare. So that we can better plan for Nebraska's future, please answer the following questions about how you access healthcare.

1. When you need to see your primary care doctor/physician, how long (in travel minutes) does it take you to travel to and from the facility from your home?
   - ◯ Less than 10 minutes
   - ◯ 10 – 20 minutes
   - ◯ 21 - 30 minutes
   - ◯ 31 - 60 minutes
   - ◯ More than 60 minutes

2. How often do you travel to a healthcare facility?
   - ◯ Never
   - ◯ Rarely (less than once per month)
   - ◯ Occasionally (1-3 times per month)
   - ◯ Regularly (4-8 times per month/1-2 times per week)
   - ◯ Frequently (3 or more times per week)

3. How do you usually get to your primary care doctor/physician's office/healthcare facility?
   - ◯ I use public transit or a van service
   - ◯ I use a taxi, Uber, or Lyft
   - ◯ I drive myself
   - ◯ A friend or family member drives me
   - ◯ I walk
   - ◯ I bike
   - ◯ Other, please specify: ______

   Go to #5

4. About how much in U.S. dollars do you spend on transportation-related expenses round-trip to get from your home to your primary healthcare facility and back?

   $ ☐,☐☐☐.☐☐ ◯ per day ◯ per week ◯ per month

5. How much do you agree or disagree with the following statements?

	Stongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a. It is important how close I live to my primary care doctor/physician's office/healthcare facility	◯	◯	◯	◯	◯
b. There are times where I am not able to get an appointment with my doctor as quickly as I would like	◯	◯	◯	◯	◯
c. The cost of transportation influences how often I visit my doctor	◯	◯	◯	◯	◯
d. I wish it was easier to get to my doctor/healthcare facility	◯	◯	◯	◯	◯
e. I would like my prescription medications to be delivered to me at home	◯	◯	◯	◯	◯

6. Would you be willing to use a driverless vehicle to take you to the doctor/healthcare facility? Why or why not?

Traveling by Driverless Car

In the following section, please consider how having a driverless car might impact your long-distance travel.

7. Driverless vehicles or self driving cars are currently being developed and tested here in Nebraska. How willing would you be to live further away from your workplace if you could get to work with a driverless vehicle?

- ◯ Very willing
- ◯ Somewhat willing
- ◯ Neither willing nor not willing
- ◯ Unwilling
- ◯ Very unwilling

8. Why are you willing or unwilling to live further away from your workplace if you could get to work with a driverless vehicle?

9. When you travel to other places in the geographic region (ex: Denver, Chicago, Minneapolis), how do you usually get there?

- ◯ Drive
- ◯ Airplane
- ◯ Train (ex: Amtrak)
- ◯ Bus (ex: Greyhound, MegaBus, Trailways)
- ◯ Other, please specify:

10. When you travel to other places in the geographic region (3 -10 hour drive from where you live), do you travel individually or with members of your immediate family?

	Yes	No
a. Myself	◯	◯
b. With spouse	◯	◯
c. With spouse and children	◯	◯
d. With just children	◯	◯

11. How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a. There are cities/places that are a 3-10 hour drive that I would like to go to more often	◯	◯	◯	◯	◯
b. I would prefer to use a driverless vehicle or self-driving car instead of <u>flying</u> to cities/places that are a 3-10 hour drive from where I live	◯	◯	◯	◯	◯
c. I would prefer to use a driverless vehicle or self-driving car instead of <u>driving</u> to cities/places that are 3-10 hour drive from where I live	◯	◯	◯	◯	◯

12. When you think about what you want transportation in Nebraska to look like in the future, what things would you like cities and the state of Nebraska working toward?

		Yes	No
a.	Investing in transportation that promotes economic development	○	○
b.	Investing in environmentally sustainable transportation options	○	○
c.	Greater investments in emerging transportation technologies	○	○
d.	Better maintenance of existing transportation networks	○	○
e.	Expanding bicycle and pedestrian infrastructure (ex: bike trails, bike lanes, sidewalks, crosswalks)	○	○
f.	Expanding public transit options	○	○
g.	Better connectivity between rural and urban areas	○	○
h.	Investing in better mass transit systems	○	○
i.	Investing in more roads and highways	○	○

Sharing the Road with Driverless Vehicles

In this section, please think about how you feel about sharing the road with other driverless cars including driverless freight and delivery trucks.

How much do you agree or disagree with the following statements?

13. I am comfortable with sharing the road with driverless cars.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

14. I would prefer sharing the road with driverless cars than with human drivers.

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

15. I am comfortable with sharing the road with driverless trucks (e.g., freight and delivery vehicles).

- ○ Strongly agree
- ○ Somewhat agree
- ○ Neither agree nor disagree
- ○ Somewhat disagree
- ○ Strongly disagree

16. I would prefer if large trucks were driverless instead of driven by human drivers.

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

17. Please tell us any additional information about your comfort level sharing the road with driverless cars.

Public Transit and Ridesharing

18. How often do you use public transit?

- Never
- Rarely (less than once per month)
- Occasionally (1-3 times per month)
- Regularly (4-8 times per month/1-2 times per week)
- Frequently (3 or more times per week)

19. How often do you use public transit when going on vacation or visiting other cities?

- Never
- Rarely (less than once per month)
- Occasionally (1-3 times per month)
- Regularly (4-8 times per month/1-2 times per week)
- Frequently (3 or more times per week)

20. How often do you use ride sharing services? (ex: Lyft, Uber)

- Never
- Rarely (less than once per month)
- Occassionally (1-3 times per month)
- Regularly (4-8 times per month/1-2 times per week)
- Frequently (3 or more times per week)

21. How often do you use ride sharing services when going on vacation or visiting other cities?

- Never
- Rarely (less than once per month)
- Occasionally (1-3 times per month)
- Regularly (4-8 times per month/1-2 times per week)
- Frequently (3 or more times per week)

22. How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly disagree
a. I feel safe using public transit.	○	○	○	○	○
b. Knowing that there is a bus or train operator/driver on board helps me feel safe.	○	○	○	○	○
c. I feel comforable letting my children (under 18) use public transit without a parent/guardian.	○	○	○	○	○
d. I would allow my children to ride on a driverless transit vehicle even if there was no bus or train operator/driver present.	○	○	○	○	○
e. My community would benefit from a driverless bus.	○	○	○	○	○
f. I feel safe using ridesharing services (Lyft, Uber).	○	○	○	○	○
g. I have felt uncomfortable while using ridesharing services (Lyft, Uber).	○	○	○	○	○
h. I feel safe letting my children (under 18) use ride share without a parent/guardian.	○	○	○	○	○
i. I would feel safe using ridesharing services if they were driverless vehicles.	○	○	○	○	○
j. I would feel safe allowing my children to use ridesharing services if there were driverless vehicles without a parent/guardian present.	○	○	○	○	○

Trust in Driverless Cars

Please consider each situation and then rate how much you think you would trust a fully-driverless car (i.e., one that drives itself and does not allow the option of a human driver to take control)

23. How much do you trust or distrust the following statements?

	Strongly trust	Trust	Neither trust nor distrust	Distrust	Strongly distrust
a. I trust driverless cars will be safe (in general)	○	○	○	○	○
b. I trust driverless cars will be safer than human drivers	○	○	○	○	○
c. I trust driverless cars to handle winter road conditions in Nebraska	○	○	○	○	○
d. I trust driverless cars more than human drivers in winter road conditions in Nebraska	○	○	○	○	○

24. Please tell us more about why you do or do not trust driverless cars.

Grocery/Food Access

25. About how far away is the grocery store you most prefer to go?

[ ][ ] Mile(s)

26. About how far away is the grocery store closest to your house?

[ ][ ] Mile(s)

27. How often do you go to the grocery store?
- ○ Never
- ○ Rarely (less than once per month)
- ○ Occasionally (1-3 times per month)
- ○ Regularly (4-8 times per month/1-2 times per week)
- ○ Frequently (3 or more times per week)

28. Do you primarily access food/groceries in each of the following ways?

		Yes	No
a.	Grocery store	○	○
b.	Convenience store (ex: gas station, corner market, etc.)	○	○
c.	Farmer's market	○	○
d.	Food pantry	○	○
e.	Food delivery services (ex: Amazon Pantry, Hy-Vee grocery delivery)	○	○
f.	Meal-prep delivery services (ex: Blue Apron, Hello Fresh)	○	○
g.	Meal delivery service (ex: Meals on Wheels, GrubHub, UberEats, Post Mates, Door Dash)	○	○

29. Have you utilized a food delivery service within the last year? (ex: Amazon Pantry, Hy-Vee grocery delivery)
- ○ Yes
- ○ No

30. Have you utilized a meal-prep delivery service within the last year? (ex: Blue Apron, Hello Fresh)
- ○ Yes
- ○ No

31. Have you utilized a meal delivery service within the last year? (ex: Meals on Wheels, GrubHub, UberEats, Post Mates, Door Dash)
- ○ Yes
- ○ No

32. How much do you agree or disagree with the following statements?

	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
a. There are times that I would like to grocery shop, but am unable to do so because of transportation limitations.	○	○	○	○	○
b. I sometimes go to a grocery store that is not my preferred grocery store because my preferred grocery store is difficult to access.	○	○	○	○	○
c. I would use a driverless vehicle to get to and from the grocery store.	○	○	○	○	○
d. If driverless vehicles were available, I would go to the grocery store more frequently than I currently do.	○	○	○	○	○
e. If driverless vehicles were available, I would go to my <u>preferred</u> grocery store more frequently than I currently do.	○	○	○	○	○

You and Your Household

33. Are you...
- ○ Male
- ○ Female
- ○ [ ]

34. In what year were you born?

[ ][ ][ ][ ]

35. What is the highest degree you have attained?
- ○ No diploma
- ○ High school diploma/GED
- ○ Some college, but no degree
- ○ Technical/Associate/Junior college (2 yr., LPN)
- ○ Bachelor's degree (4 yr., BA, BS, RN)
- ○ Graduate degree (Master's, PhD, Law, Medicine)

36. Do you typically work full-time, part-time, go to school, keep house, or something else? *(Check all that apply)*
- ☐ Work full-time (35 hours or more)
- ☐ Work part-time
- ☐ Have a job, but not at work (due to illness, vacation, or strike)
- ☐ Unemployed, laid off, looking for work
- ☐ Retired
- ☐ In school
- ☐ Keeping house
- ☐ Disabled
- ☐ Other, please specify: [ ]

37. Please indicate the category that describes your total family income in the last 12 months.
- ○ Under $24,999
- ○ $25,000 to $34,999
- ○ $35,000 to $49,999
- ○ $50,000 to $74,999
- ○ $75,000 to $99,999
- ○ $100,000 or more

38. Do you consider yourself to be Hispanic or Latino/a?
- ○ Yes
- ○ No

39. What race or races do you consider yourself to be? *(Check all that apply)*
- ☐ White (Caucasian)
- ☐ Black or African American
- ☐ Asian
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Other Pacific Islander
- ☐ Other, please specify: [ ]

40. Including yourself, how many adults age 19 and older live in your household?

[ ][ ]

41. How many children age 18 and younger live in your household?

[ ][ ]

42. Do you live on a farm, in open country but not on a farm, or in a town or city?
- ○ Farm
- ○ Open country, but not a farm
- ○ Town or city

43. How many years have you lived in this Nebraska county?

[ ][ ]

44. Please use the space below to provide any comments.

[ ]

Thank you!

That completes our questions. We greatly appreciate the time you have taken to complete this survey. For your convenience, please use the postage-paid return envelope included in your survey packet to return your questionnaire to the Bureau of Sociological Research.

Phone: 1-800-480-4549 (toll free)
E-mail: bosr@unl.edu

Appendix B: Communication Language

Invitation Letter

Nebraska University of Lincoln

COLLEGE OF ARCHITECTURE

DATE

«City» Resident
«Street» «Apt»
«City», «STATE_ABBR» «ZIP»-«ZIP4»

Dear «City» Resident,

We are writing to ask for your help with an important study. With driverless transportation becoming more prevalent, we would like to know the impact it could have on the future of Nebraska. This study asks questions about your opinions regarding driverless transportation technology and your transportation needs. Results of this study will allow us to understand current and future transportation challenges Nebraskans face. Your answers will help us to better understand how to improve transportation planning and what people from all areas of Nebraska think of new transportation technologies, such as driverless transportation potentially coming to Nebraska.

We rely on the kindness of people like you to make the survey work. Please have the **adult age 19 or older in your household who has the next birthday after February 1st, 2020** do the survey. This results in a random sample.

The survey should only take about 15-20 minutes to complete. Your participation is voluntary and all responses will be kept confidential. There are no risks to participating in this survey. Results will only be reported in the aggregate, and only de-identified data will be shared with the researchers.

We are happy to answer any questions you have about this survey. You can contact the Bureau of Sociological Research at the University of Nebraska-Lincoln (UNL), who is helping me with this survey, by telephone at 1-800-480-4549 or by email at bosr@unl.edu. If you have any additional questions or comments about this study, do not hesitate to contact me at (402) 472-9239 or dpiatkowski2@unl.edu. This study has been reviewed and approved by the UNL Institutional Review Board (IRB# 20200119999EX). If you have questions about your rights as a participant, you may contact them at 402-472-6965.

Thank you for helping us make this study a success.

Sincerely,

Daniel Piatkowski
Assistant Professor
Community and Regional Planning
University of Nebraska-Lincoln

210 Architecture Hall / P.O. Box 880106 / Lincoln, NE 68588-0106
(402)472-9212 / FAX (402) 472-3806 / Email: architecture@unl.edu / http://architecture.unl.edu

«ID»

Postcard Reminder

Front

UNIVERSITY OF Nebraska Lincoln

DEPARTMENT OF SOCIOLOGY
Bureau of Sociological Research

907 Oldfather Hall
P.O. Box 880325
Lincoln, NE 68588-0325

RETURN SERVICE REQUESTED

NON PROFIT
US POSTAGE
PAID
UNL

Back

[DATE]

Dear [City] Resident,

A questionnaire was sent to you last week because your household was randomly selected to participate in a study about current and future transportation challenges you may experience in Nebraska. If someone at your address has already completed and returned the questionnaire, please accept our sincere thanks. If not, please have the **adult age 19 or older in your household who will have the next birthday after February 1st, 2020** complete the questionnaire right away. We appreciate your help with this study.

While participation is voluntary, you can help us by having the correct person in your household take a few minutes to share their experiences. If you did not receive a questionnaire or if it was misplaced, please call 1-800-480-4549 and we will send another one immediately. Again, we appreciate your help and look forward to receiving your questionnaire.

Daniel Piatkowski
Community and Regional Planning
University of Nebraska-Lincoln

Reminder Letter

COLLEGE OF ARCHITECTURE

[DATE]

«City» Resident
«Addy1» «Addy2»
«City», «STATE_ABBR» «ZIP»-«ZIP4»

Dear «City» Resident,

A few weeks ago we sent a letter asking a member of your household to complete the Nebraska's Driverless Survey. We are writing again because we have not yet received your household's response. We believe this survey will help us to understand current and future transportation challenges in Nebraska. We also hope to use the information gathered to inform planning and the development of new transportation technology.

We are writing again because your survey is important to us. We hope the **adult age 19 or older in your household who has the next birthday after February 1st 2020** will complete the questionnaire soon.

As noted in the first survey mailing, your answers are completely confidential, no individual's information is identified, and you do not have to answer any question(s) you do not want to answer. However, you can help us by taking a few minutes to complete the survey. If for any reason you prefer not to complete it, please let us know by returning a note or blank survey in the enclosed postage paid envelope.

You can reach the Bureau of Sociological Research at the University of Nebraska-Lincoln (UNL), who is helping me with this survey, at 1-800-480-4549 or by email at bosr@unl.edu with any questions. If you have any additional questions or comments about this study, do not hesitate to contact me at (402) 472-9239 or dpiatkowski2@unl.edu. If you have questions about your rights as a participant in this or any study conducted at UNL, you may contact the UNL Institutional Review Board at 402-472-6965. This study has been reviewed and approved by them (IRB# 20200119999EX).

We really appreciate your help with this important survey.

Sincerely,

Daniel Piatkowski
Assistant Professor
Community and Regional Planning
University of Nebraska-Lincoln

210 Architecture Hall / P.O. Box 880106 / Lincoln, NE 68588-0106
(402)472-9212 / FAX (402) 472-3806 / Email: architecture@unl.edu / http://architecture.unl.edu

«Sample»

Appendix C: Estimate of Sampling Error

Table 1 displays the Nebraska's Driverless Future Survey data by the variables used in weighting. One can compare the results weighted and unweighted from the Nebraska's Transportation Future Survey compared to the Census information in order to see the effects of weighting.

Table 1. Representativeness of the Nebraska Driverless Survey Sample by Weighting Variables

	Based on 2010 Census	Unweighted	Weighted
Male	48.5%	43.2%	49.1%
Female	51.5%	56.4%	50.4%
19-44	46.2%	20.3%	45.8%
45-64	35.3%	37.7%	35.8%
65+	18.4%	42.0%	18.4%

Table 2 presents margins of sampling error for some of the most likely sample sizes *not* taking the design effect from the weighting into account. Exact margins of error for alternative specifications of sample size and reported percentages can be easily computed by using the following formula for the 95% confidence level:

Margin of error = 1.96 * square root (p(1-p)/n)

p = the expected proportion selecting the answer

n = number of responses

Table 2. Approximate Margins of Error of Percentages by Selected Sample Size NOT Accounting for Design Effect

Reported Percentage	Full Sample* n=612	75% Sample n=459	50% Sample n=306	33.3% Sample n=204	25% Sample n=153	10% Sample n=61
50	3.96%	4.57%	5.60%	6.86%	7.92%	12.55%
40 or 60	3.88%	4.48%	5.49%	6.72%	7.76%	12.29%
30 or 70	3.63%	4.19%	5.13%	6.29%	7.26%	11.50%
20 or 80	3.17%	3.66%	4.48%	5.49%	6.34%	10.04%
10 or 90	2.38%	2.74%	3.36%	4.12%	4.75%	7.53%
5 or 95	1.73%	1.99%	2.44%	2.99%	3.45%	5.47%

*95% confidence interval states that in 95 out of 100 samples drawn using the same sample size and design, the interval will contain the population value

When accounting for design effects due to weighting, the adjusted sampling error will be increased as is shown when comparing Table 2 to Table 3 where the sampling design effect is incorporated:

Margin of error = square root (deff) * 1.96 * square root (p(1-p)/n)

deff = design effects

p = the expected proportion selecting the answer

n = number of responses

Table 3. Approximate Margins of Error of Percentages by Selected Sample Size Accounting for the Design Effect of Weighting

Reported Percentage	Full Sample* n=612	75% Sample n=459	50% Sample n=306	33.3% Sample n=204	25% Sample n=153	10% Sample n=61
50	6.66%	7.69%	9.42%	11.53%	13.32%	21.09%
40 or 60	6.52%	7.53%	9.23%	11.30%	13.05%	20.67%
30 or 70	6.10%	7.05%	8.63%	10.57%	12.21%	19.33%
20 or 80	5.33%	6.15%	7.53%	9.23%	10.65%	16.87%
10 or 90	4.00%	4.61%	5.65%	6.92%	7.99%	12.66%
5 or 95	2.90%	3.35%	4.11%	5.03%	5.81%	9.19%

* 95% confidence interval states that in 95 out of 100 samples drawn using the same sample size and design, the interval will contain the population value

Appendix D: Sample Design

Stratum 1 – Urban Large

- Cass
- Lancaster
- Douglas
- Sarpy
- Saunders
- Seward
- Washington

Stratum 2 – Urban Small

- Adams
- Buffalo
- Dakota
- Dawson
- Dixon
- Dodge
- Gage
- Hall
- Hamilton
- Howard
- Lincoln
- Madison
- Merrick
- Platte
- Scotts Bluff

Stratum 3 - Rural population

- Antelope
- Arthur
- Banner
- Blaine
- Boone
- Box Butte
- Boyd
- Brown
- Burt
- Cedar
- Chase
- Cherry
- Cheyenne
- Clay
- Colfax
- Cuming
- Custer
- Dawes
- Deuel
- Dundy
- Fillmore
- Franklin
- Frontier
- Garden
- Furnas
- Garfield
- Gosper
- Grant
- Greeley
- Harlan
- Hayes
- Hitchcock
- Holt
- Hooker
- Jefferson
- Johnson
- Kearney
- Keith
- Keya Paha
- Kimball
- Knox
- Logan
- Loup
- McPherson
- Morrill
- Nance
- Nemaha
- Nuckolls
- Otoe
- Pawnee
- Perkins
- Phelps
- Pierce
- Polk
- Red Willow
- Richardson
- Rock
- Saline
- Sheridan
- Sherman
- Sioux
- Stanton
- Thayer
- Thomas
- Valley
- Wayne
- Webster
- Wheeler
- York

Appendix E: AAPOR Transparency Initiative Immediate Disclosure Items

1. Who sponsored the research study.
   Introduction
2. Who conducted the research study.
   Introduction
3. If who conducted the study is different from the sponsor, the original sources of funding will also be disclosed.
   Introduction
4. The exact wording and presentation of questions and response options whose results are reported. This includes preceding interviewer or respondent instructions and any preceding questions that might reasonably be expected to influence responses to the reported results.
   Appendix A
5. A definition of the population under study and its geographic location.
   Sampling Design
6. Dates of data collection.
   Data Collection Process
7. A description of the sampling frame(s) and its coverage of the target population, including mention of any segment of the target population that is not covered by the design. This many include, for example, exclusion of Alaska and Hawaii in U.S. surveys; exclusion of specific provinces or rural areas in international surveys; and exclusion of non-panel members in panel surveys. If possible the estimated size of non-covered segments will be provided. If a size estimate cannot be provided, this will be explained. If no frame or list was utilized, this will be indicated.
   Sampling Design
8. The name of the sample supplier, if the sampling frame and/or the sample itself was provided by a third party.
   Sampling Design
9. The methods used to recruit the panel or participants, if the sample was drawn from a pre-recruited panel or pool of respondents.
   Not applicable to project
10. A description of the sample design, giving a clear indication of the method by which the respondents were selected, recruited, intercepted or otherwise contacted or encountered, along with any eligibility requirements and/or oversampling. If quotas were used, the variables defining the quotas will be reported. If a within-household selection procedure was used, this will be described. The description of the sampling frame and sample design will include sufficient detail to determine whether the respondents were selected using probability or non-probability methods.
    Sampling Design and Data Collection Process
11. Method(s) and mode(s) used to administer the survey (e.g., CATI, CAPI, ACASI, IVR, mail survey, web survey) and the language(s) offered.
    Questionnaire Design

12. Sample sizes (by sampling frame if more than on was used) and a discussion of the precision of the findings. For probability samples, the estimates of sampling error will be reported, and the discussion will state whether or not the reported margins of sampling error or statistical analyses have been adjusted for the design effect due to weighting, clustering, or other factors. Disclosure requirements for non-probability samples are different because the precision of estimates from such samples is a model-based measure (rather than the average deviation from the population value over all possible samples). Reports of non-probability samples will only provide measures of precision if they are accompanied by a detailed description of how the underlying model was specified, its assumptions validated and the measure(s) calculated. To avoid confusion, it is best to avoid using the term "margin of error" or "margin of sampling error" in conjunction with non-probability samples.
    Sampling Design, Design Effect, and Appendix C
13. A description of how the weights were calculated, including the variables used and the sources of weighting parameters, if weighted estimates are reported.
    Data Weights
14. If the results reported are based on multiple samples or multiple modes, the preceding items will be disclosed for each.
    Not applicable to project
15. Contact for obtaining more information about the study.
    Questions